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POPULAR SCIENCE MONTHLY.

NOVEMBER, 1874.

THE NATURAL HISTORY OF THE OYSTER.

By Rev. SAMUEL LOCKWOOD, Ph. D.

I.

AN illiterate fisherman once became wellnigh eloquent in his effort to describe to us the treasures which the waters offered freely to man. Nature is, indeed, lavishly opulent. Among the food-treasures of this bounteous harvest of the sea, the oyster ranks high in the general esteem. And deservedly so, for she is truly the queen of the bivalves. Let us try to tell the story of her life.

Oyster-Planting.—For a creature of such lowly rank in the scale of animate being, it is wonderful what a literature attaches to the oyster. Through the roll of the ages it has been a factor of prime importance in the convivial instincts, the moralities, and the industries of men. It has honorable mention in classic song and story. When imperial Rome had her many million populace, and her almost fabulous wealth, the oyster figured prominently in the more than lavish luxury of that extravagant city. Do our oyster-growers know how ancient their calling is? About 2,400 years ago one Sergius Orata, a man of a practical mind, turned Lake Avernus into an oyster-bed; and through his culture of this bivalve the Lucrin oysters, as they were called, became in reputation the "Saddle-Rocks" of Rome. And what a splendid market he had! His practical genius carried the new industry of oyster-planting to great perfection; and such was his reputation in that line that the Romans had a saying that, should the oysters stop growing in Lucrin Lake, Sergius would make them grow on the tops of the houses. Avernus has at last succumbed to the mutations of time, and is to-day a miserable hole of volcanic mud. It now offers a good opportunity to test the great man's abilities; but Sergius Orata himself "dried up" some time ago.

Near Baiæ and Cumæ is the Neapolitan Lake Fusaro (Fig. 1). This was the classic Acheron. It is about three leagues round, and is hardly

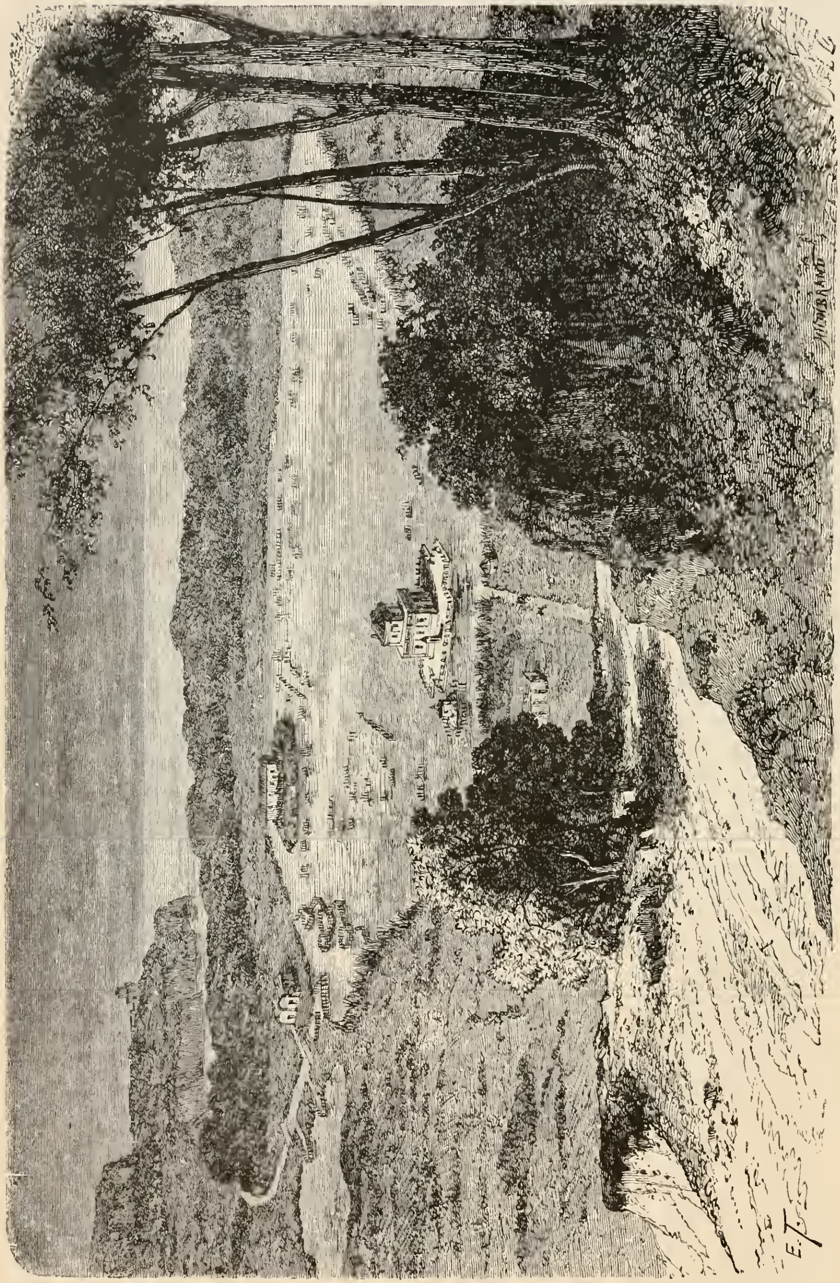

Fig. 1.—Lake Fusaro and its Oyster-Plantations.

in any part more than six feet deep. Its bed is a black volcanic slime, such as one might suppose would be death to mollusks generally. From time beyond memory this has been an oyster park or plantation; a place for raising the young oysters, that is, the oyster-seed—namely, the small oysters, which, when put in proper places, will become oysters of an eatable size. For these young to settle on, heaps of stone are placed in the lake with a circle of piles round each heap (Fig. 3). In other parts of the lake the piles are driven in rows and connected by ropes, from which hang fagots, on which also the young can fix themselves (Fig. 4). These fagots, at the proper time, are easily pulled up, and the young, or "seed," picked off by hand to be planted elsewhere.

Formerly France possessed a great abundance of native oysters. But this industry was without regulation, and the French natives, like our Northern natives, came near being exterminated. A few years ago Prof. Coste, of the French Academy, called attention to the fact that the French oyster was becoming extinct. He took up the study of this mollusk in earnest, and learned many important facts concerning its nature. He even went to the Neapolitan oyster-park, and observed how the fishermen there saved the young ones. He then appealed to the government, which put means in his way for experimenting, and, in a short time, he had a successful oyster-plantation under way. It is in France as elsewhere, "seeing is believing," and "there is nothing that succeeds like success." Under the wise direction of this learned naturalist the new industry, oyster-planting, became a furor in France. "In two years 1,200 capitalists, associated with a similar number of fishermen, occupied a surface of 988 acres." By which is meant the area of shore-line exposed at low tide. And what labor! so thorough and scientific. The isle of Ré, with its unsuitable, muddy shores, had all that sea-bottom altered. In two years twelve miles of sea-coast thus changed was planted, with 1,200 parks in operation, and thousands more projected. Now, oyster-culture is conducted in France on better principles than anywhere else. And all of this great additional wealth to the nation comes out of the applied science of a man "that studied shells and worms," as is often said in derision. In France scrupulous provision is made for husbanding the fry. In America no effort is made in this direction, and the time is not far off when the nation will wake up to a serious calamity in this respect.

The American practice is simply this: In the spring of the year large numbers of sloops and schooners go south to procure the young oysters called "seed." This sets considerable money afloat southward, as they have to take with them the ready cash. In the days of "wild-cat" banking, the Southrons would take nothing but specie, and that must be paid just so soon as the oysters were put into the boat. The "seed" is obtained chiefly in the Rappahannock, the Nanticoke, and a few other places. Oysters also of a moderate size are often brought north and laid down for a season, that they may increase in size and acquire something of the flavor of the Northern native, so superior to that of the Southern. The better kinds of the Southern, such as the Lynn Haven Bays, Sandy Points, Cherrystones, York Rivers, etc., are sent for immediate consumption to Baltimore, Washington, Philadelphia, and some to New York. New Jersey,

Fig. 2.—European Oysters: Five Groups of Different Ages growing on a Stick of Wood.

New York, and Connecticut, are the favorite planting-grounds. When the vessels return with the young oysters they are planted, that is, scattered over the beds. As the lower side of the oyster is the heavier, this generally secures its falling right side up. The seed, or young oyster, is allowed to lie for from one to two years, seldom three, when it is considered ready for market, and in that time it has greatly improved in quality. Early in the fall the work of taking up the crop begins. This is done by what is called tonging. An instrument is used called oyster-tongs. Something of an idea of it may be got by supposing two garden-rakes with very long handles, with the tooth-side of each rake facing each other; let the handles be secured by a loose rivet about two or three feet from the teeth, so that by operating the extreme ends of the handles the whole contrivance shall act as a pair of tongs. Working over the side of his boat, the oysterman and his comrade thus take up the first of the harvest. After tonging,

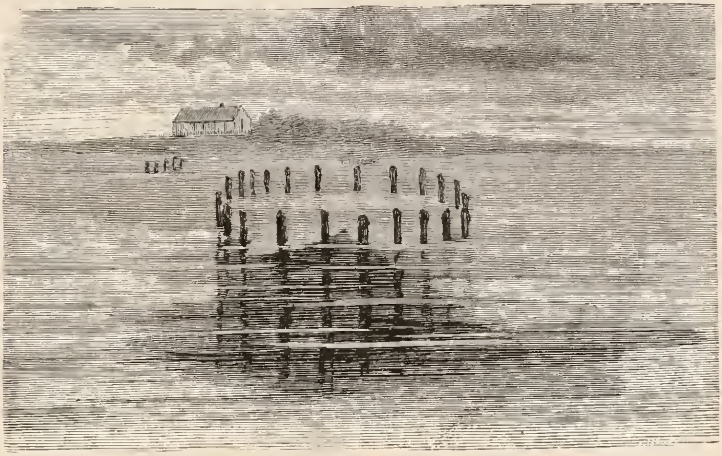

Fig. 3.—Artificial Oyster-Bank in Lake Fusaro.

the bed is again gone over, but this time with the dredge (Fig. 5). In this process a vessel with sails must be used (Fig. 6). The great iron bag or dredge is cast into the water and dragged along the bottom. Then (and terrible hard work this is) it is drawn up, and its contents are emptied on deck. Whether tonging or dredging, oystering requires broad-chested men, with sturdy hands and arms. The oysters are next taken a little way up a fresh-water creek or stream, into which they are thrown "to get a drink." The process sweetens and cleanses them. One day, often even one tide, is enough for this purpose. As the water is not deep, the mollusks are taken up with large forks. The workmen stand in the stream, wearing very high rubber boots. When late in the fall, this is intensely cold work. Before being thrown into the fresh water, a sorting process is gone through. There are dead oysters, and winkles, and conchs, and stones, and many useless matters, to be separated. All this is thrown upon the banks of the stream. After being taken out of the stream, before they can be sent to the great city, comes the process called "culling," that is, assorting into the sizes known in the trade. The smallest are called "culls," and are sold by the bushel. These are used in making the popular "stews" of the saloons; also, when opened, it is this sort that is sold by the quart for domestic use. The others are known as "count," and the restaurants serve them up as "fries," and on the half-shell, as raw. These are sold by the hundred.

After the harvest is finished, not a few oysters will yet remain on the beds. The grounds are then given up to the laborers who have worked them on hire. Under a new impulse these men go over the grounds again with tongs and dredge. They work on shares usually, returning to the owner of the beds one-half of the results, which makes a really handsome thing for the gleaners, whose work in this way lasts from two to three weeks, making three or four days a week, each man often clearing as his portion from four to five dollars a day. At any rate, such generally is the practice with its results at Keyport, N. J., where for many years the principle of the good old biblical rule, of not forgetting the gleaners, is almost religiously observed in the last gathering of this harvest of the sea.

Local Varieties.—It is generally conceded that the Northern oyster is superior to the Southern. Upon this understanding, and the fact that formerly the Southern oysters that were brought north were chiefly procured from Chesapeake Bay, and the favorite Northern natives were got around and near New York, the old oystermen used to speak in general terms of two kinds, the Southern and the Northern, which they designated as "Chesapeakes" and "York Bays." There are, however, a great many local names, which are supposed to indicate special excellences. All these northern edible oysters are of one species, *Ostrea borealis.* Some naturalists, however, claim that the Southern is different, and should be called *Ostrea Virginiana.* But for the plain reason that both varieties can any day be found in any oyster-bed in Long Island Sound, and indeed they seem to change by growth indiscriminately into each, a more rigid science would refer them all to the name given by Lister—*Ostrea Virginiana.* Yet, take them in the mass, and any experienced oysterman will tell the Southern from the Northern. The European oyster is called *Ostrea edulis;* but that it is sufficiently different to make a distinct species is far from certain. Experienced dealers will pick out the local varieties of the Northern article. Of these we have many names—such as the Keyport, City Island, Guilford, Blue Point, Rockaway, Saddle-Rock, Shrewsbury, etc. The Blue Point was for fifty years "the Knickerbocker among oysters." It was raised chiefly in Great South Bay. This fine oyster had to yield on the appearance of the splendid Saddle-Rocks. This name is still given to all very large oysters, and generally to those taken in the East River. It is, however, no longer in existence. They were first brought to Fulton Market, New York, by an old negro named Henry Scott. The following, by our friend Dr. O. R. Willis, is authentic. It appeared in the *New York Observer:*

"The original Saddle-Rock oyster was not only very large, but possessed a peculiar, delicious flavor, which gave it its reputation. And it received its name because it was discovered near a rock known as Saddle-Rock. A high northwest wind, continued for several successive days, always causes very low tides in Long Island Sound and its bays. On the farm of David Allen, situated near the head of Great Neck, on the eastern shore of Little Neck Bay, is a rock about twenty feet high, and from fifteen to twenty feet in diameter. The shape of the top of this rock resembles somewhat the form of a saddle, and from that circumstance is called Saddle-Rock. At low water the upper or land side of this rock is left bare, while the opposite or lower side is in the water. In the autumn of 1827, after a strong northwest wind had been blowing for three days, a very low tide occurred, and the water retreated far below the rock, leaving a space wide enough for a team of oxen to pass quite around it. This extraordinary low tide revealed a bed of oysters just below the rock. The oysters were very large, and possessed the most delicate flavor;

FIG. 4.—FAGOTS SUSPENDED FROM ROPES, TO SERVE AS ATTACHMENTS FOR OYSTER-SPAT, IN LAKE FUSARO.

we collected cart-loads of them, and placed them in our mill-pond (tide-mill). The news of the discovery spread among the oystermen, and boat-loads soon found their way to the city, where, on account of their excellent flavor, they commanded fancy prices, even reaching ten dollars a hundred!—an enormous price for those days. In a very short time the locality was exhausted, and for more than forty years there has not been a real Saddle-Rock oyster in the market."

At present the favorite native is the Shrewsbury, which is mainly obtained by planting, in the Shrewsbury River, seed procured from Tappan Bay. Of this seed there will be in a bushel about 2,500 young oysters, costing about 60 cents. After two years' growth, 200 will fill that measure. At present the Shrewsbury is accounted by many as the emperor of the bivalves, and will fetch in market at wholesale from $1.50 to $3.50 a hundred. What is called the summer oyster is brought from the York and James Rivers, Va., and planted north late in the season for summer use.[1] Some are brought from the waters of Maryland.

The Oyster-Trade.—Dragon, as it used to be called, Fair Haven now, near New Haven, was formerly *the* place where oysters were put up for Northern and Western use. The bivalves were opened and put into neat little kegs. Latterly the business has gone down to Baltimore. "Shipping is yearly becoming more extensive, and Baltimore —though ahead at present—has a powerful rival in the metropolis, as all roads lead to it, like those of the ancient world to Rome. In October the shipping to Europe and California commences, and latterly tubs instead of sealed cans are used. In shipping to St. Louis, Cincinnati, and other places within a distance of a thousand miles, oysters are shipped in cold weather in kegs protected by gunny-bags, but in summer the kegs are placed in larger vessels and the space packed with ice and sawdust. So expert has experience rendered the shipper that oysters seldom spoil, and the Western purchaser may rejoice in a comparatively fresh and wholesome article."

Even in the northern parts of the State of New York, thirty years ago, oysters were an unknown luxury. But the rapid transit "which has been developed in the last quarter of a century has given a great impulse to exportation, and statistics from reliable sources show that many millions of dollars' worth of oysters are yearly sent from this port alone. For instance, the average retail trade per week of Fulton Market requires 250,000 oysters, and one establishment is called upon to supply from 1,000 to 1,500 customers daily. The wholesale department packs and exports 100,000 weekly, and gives employment to a large number of men.

"The yearly returns from the home-market amount to $4,000,000 per annum, and from other localities to about $1,000,000. The trade gives employment to 2,500 men in New York City, and to 200 in Brooklyn. There are 750 oyster-saloons in the metropolis, and 100 in the City of Churches. On the North and East Rivers about 50 scows are employed receiving oysters from the vessels arriving from these various bays, and from these boats about 3,000,000 oysters are daily shipped throughout the country. Five hundred sailing-vessels are employed in this vicinity, which number includes every thing from a sail-boat to a schooner of 150 tons. A corps of 5,000 men is engaged in planting and bringing to market, who earn on an average from three

[1] For some of the facts cited above, and in a few paragraphs immediately following, I am indebted to an able article in the *Brooklyn Eagle*, the date of which I cannot tell.—S. L.

to four dollars per day. In fact, it may be safely estimated that about 10,000 men, directly or indirectly, make a living in the oyster-trade of the two cities. Many of the ancestors of the wealthiest Knickerbocker families were oystermen, and at the present day many a bluff, rugged-looking man engaged in this business has a bank account that more pretentious people, living in a brown-stone house, might well envy."

American oysters are now being shipped to Europe by steamer. The first ventures proved disastrous. They were shipped in bulk in the vessel's hold. They "spoiled," that is, perished, doubtless from the warmth and want of air, as oysters are often carried by sail-vessels from the South to the North safely, although they may be longer on the way than the steamer, and even carry larger quantities in bulk. These vessels employed by the oystermen carry, according to the vessel's capacity, from 1,800 to 2,800 tubs, a tub being a bushel and a half. But, though oysters were at first lost in their transit by steamer, they now go more safely, being put up in barrels, instead of in bulk. And this business of oyster transportation is destined to assume immense proportions; hence the following from the *World* of December 22, 1873, may become an item in history: "N. B. Mulliner, A. W. Mead, Oliver Charlick, and Miles Smith have formed a company for the shipment of oysters to the London market, and made their first consignment during the past week from Freeport. It is proposed to sell the oysters on commission."

An experiment, the results of which, if successful, will be followed by great consequences, is a recent attempt made to acclimatize the New Jersey oyster in California. Joseph Ellsworth, a heavy operator in this bivalve, who owns one of those floating establishments known as scows, affairs of immensely greater importance than the name would imply, made a very interesting venture last fall. He freighted a car with the "seed" for San Francisco. The seed was obtained in Newark Bay, and 60 cents per bushel were given for it in the rough, that is, as it adhered to shells, etc. The best and cleanest were selected, averaging in size about that of the old copper cent. The cost of this seed would be about $8 per bushel at its delivery in San Francisco. It is estimated that two years' growth will suffice for this market, where they will be more easily suited on the question of size than the people East. It is also expected that, after the spawning-season is safely passed over, enough stock, or seed, will be had to make future operations successful. Of course, the whole matter is, as yet, an experiment. The native Californian oyster is a puny affair, and it is to be feared that the Eastern oyster will degenerate in Pacific waters. We shall see. Meanwhile the experimenter deserves great praise for the energy shown in his bold venture.

The Risks.—It will be news to many to hear that the business of the oyster-producer is one of great risk. All is not gain to these industrious people, for often capital is sunk in the waters that is never taken up. Many years ago we remember the then small village of Keyport suffering a loss in one season of $50,000. Even a severe storm continued unusually long has smothered the beds by agitation of the mud, for the oyster must keep its nib out of the bottom. But two seasons ago, in one of the branches of Shrewsbury River, a crop was almost entirely lost, the supposition being that it was poisoned by the washing from a new turnpike, in the construction of which a peculiar ferruginous earth had been used. Formerly the oyster throve as a native as high up the North River as Peekskill, and probably its limit was not below fifty miles from the mouth of the river. They are now, however, exceedingly scarce, even as high as Croton. The belief exists that the railroad has destroyed them by the washing from the necessary working of the road, which is constantly finding its way to the river-bed. So long ago as 1851, Colonel John P. Cruger, of Cruger's Landing, a very intelligent observer, called our attention to the fact of the mischief thus done.

And there are meteoric causes which affect the oyster. We have known an unusually severe winter to kill the bivalves in great numbers. And even the seed in its transport from Virginia has been destroyed—whole valuable cargoes—by foggy weather, and adverse winds. Moreover, as will be seen, the oyster has its deadly enemies in the animate ranks.

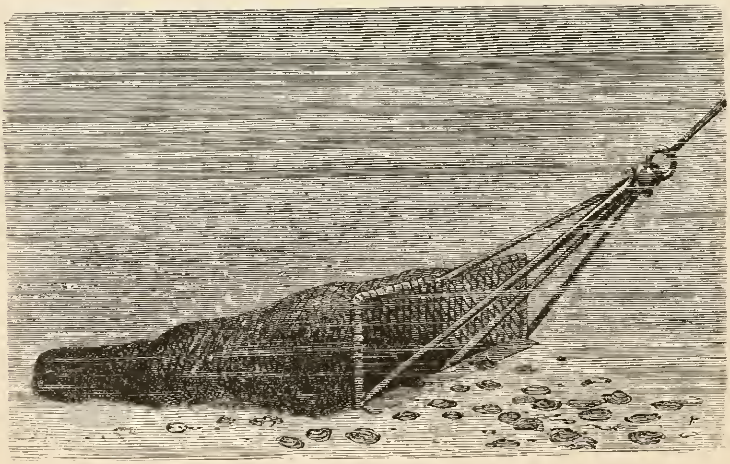

Fig. 5.—An Oyster-Dredge at work.

The Physiology of the Oyster.—By persons engaged in the business, we have been asked, "Are there hes and shes among the oysters?" The answer of the naturalist would be, "There are not." Low down in the scale of life many animals on their sexual side are singularly suggestive of plants. Take, for example, that splendid grass, *Zea mays*—Indian-corn. On the top of this graceful plant is a large, brush-like panicle. This contains the staminate or male flowers. Embedded in the green cob of the ear are the pistillate or female flowers. Their pistils make the tassel, which is called "the silk." Upon these falls the fertilizing pollen of the stamens from the raceme above. Without this contact there would be no kernels on the cob. In some plants this bisexuality occurs in the same flower. A notable instance is that of the prolific strawberry known as Wilson's Albany Seedling. A similar fact, certainly an analogous one, is true of the oyster. It is bisexual. It is not masculine alone, nor feminine alone, but both; and perhaps might be defined by that innovation in modern grammar, as of "the common gender." It is hermaphroditic.

The question of the parental relation of the young oyster on its paternal side is most certainly a very perplexing one; for, albeit no matrimonial dereliction was ever known among these Ostreæ, yet the fact remains that no oyster was ever begotten that knew its own father.

If, now, the reader will take a little pains to compare our description of the organism of the oyster with Fig. 7, he will see that, however lowly the oyster may be regarded, it has a compact and even a complex anatomical structure, manifestly a beautiful adaptation to the creature's necessities; and even exhibiting, in a very instructive manner, a wonderful likeness to our own organization. If this seems a startling position, let the reader follow the discussion, and see if it be not made good. If we take an oyster in the hand, it will be observed that, of the two valves or shells, one is much deeper and heavier than the other. This is the bottom or lower valve, because, when lying undisturbed on the bed of the water, it is the under side. The upper valve is often a mere thin plate of shell. It is observable, too, that generally the lower valve is, on the outside, quite convex, while the upper one is usually either flat or a little concave. Let it now be remembered that, anatomically, an oyster has also two sides, and that while living its normal position is to lie on its left side. The valve, then, represented by the cut, is the lower or deep valve, in popular speech, but in scientific phrase it is the left valve. The oyster itself is shown as representing what is popularly known as its upper side, the side seen when eaten on "the half-shell;" correctly speaking, it is the right side of the animal.

Let us now follow the index-words of the figure. We find a thin sheet of flesh lying on the shell. It is the left mantle, for there are two, one to cover the right side also, so that both together are continuous as one, and with it the animal inwraps itself.

The figure shows a portion of the right or upper lobe of the mantle. It is sometimes called the pallium, and really is the oyster's cloak, though it is always and only worn in the house. This is not true, however, of all the mollusca. The beautiful cowries, so high colored and bright, are exceptions. If you examine a common tiger

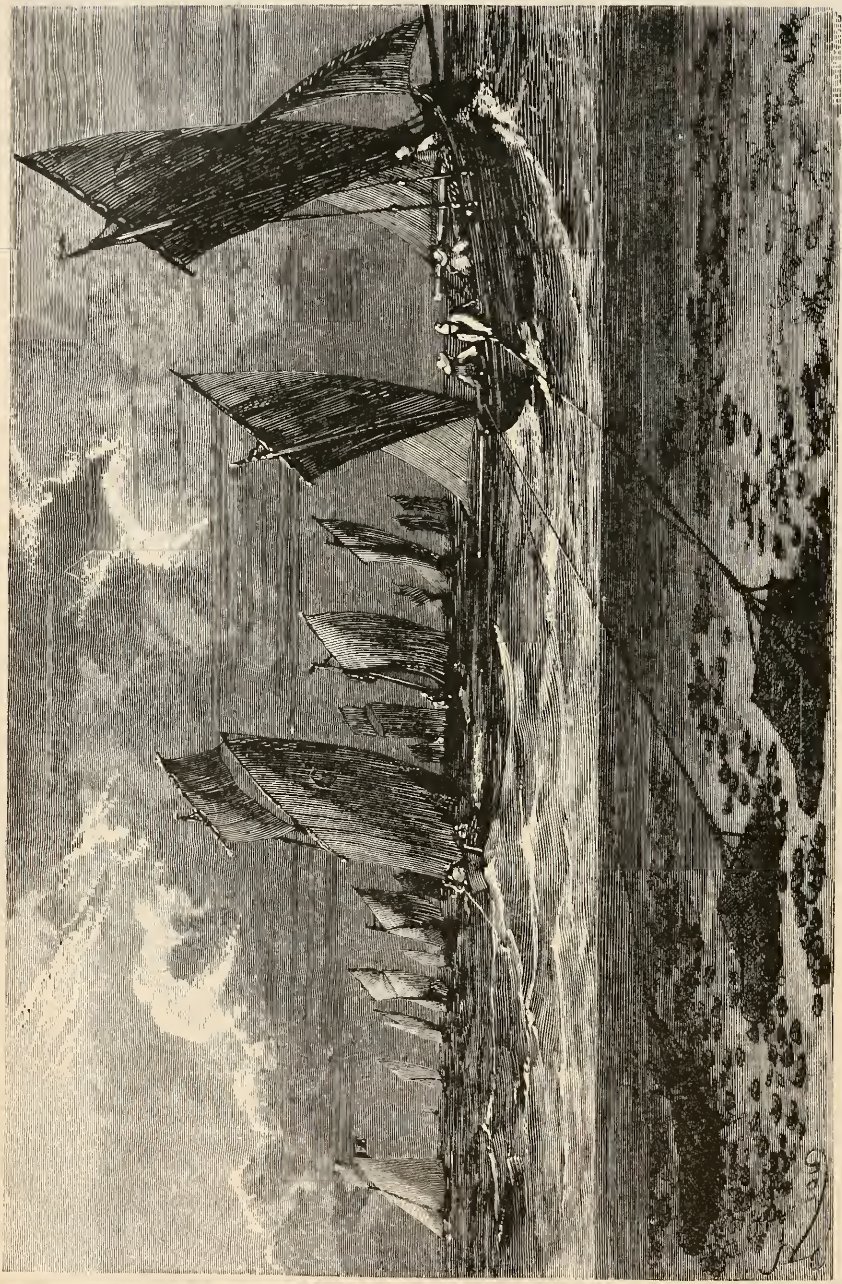

Fig. 6.—Vessels dredging for Oysters.

cowry or Cypræa, if an adult shell, you will find that, while the entire shell is covered with a shining enamel, there is along the whole length of the back of the shell "a line of pale color." The animal extends both folds of the mantle outside of itself and over the shell, and that line is where the lips of the folds meet. This mantle has much to do with obtaining food. The oyster opens its shells about a quarter of an inch apart. These membranes, that make the mantles from both sides of the animal, meet just at the opening of the shell. They are fringed at their edges with rows of tiny cilia, or soft fleshy hairs of extreme delicacy. This pallial fringe in an eminent degree serves the oyster as organs of touch. Probably this sense, though distributed somewhat over the entire surface of the body, is along this fringe exquisitely acute. The English call this fringe the oyster's beard. It is protruded just a little out of the shell; and these cilia, almost numberless, keeping up their rapid movements in the water, make as it were two parallel vibrating curves, which beget a sort of aquatic vacuum inside the shell, into which the water flows, as in a diminutive whirlpool. The stream thus affected brings with it the algæ spores and animalcules which constitute the oyster's food. But where is the oyster's mouth? Speaking popularly, it is away back near the hinge of the shell, as shown in the cut. To this point the current flows. Now, it must not be supposed that all is fish that comes to the oyster's net. Far from it. Hence this mollusk has eclectic functions. Doubtless a sharp spicule of a sponge may occasionally get into the mouth, even as a bone splinter can get by accident into a human throat. The word "tentacles," in the cut, refers to certain organs, that might be called labial or lip fingers. These, it will be noticed, have immediate relation to the mouth. They are the organs for discriminating food—functionally they are manipulating lips. The stomach is not shown in the cut, being overlaid by the other organs. The intestine, at least a part of it, is exposed, and its extremity is really the anus or vent. So much, then, is apparent, that the oyster possesses an alimentary system of some complexity.

A series of plates or plaited frills, lies on the mantle, if indeed it is not a specialized portion of that organ. These plaits are the branchiæ or gills. In the respiratory system of an oyster these branchiæ or gills are precisely the same to it as are the gills to a fish, or our lungs to us. Through these gills the water is passed. After imparting to the blood the oxygen taken from the air which the water contained, that water, now laden with carbonic-acid gas, is expelled at the respiratory aperture, or ex-current orifice, the dark spot in the figure immediately under the end of the intestine, which we have already said is the anus or vent, whence this refuse water, like a cleansing stream, passes directly out of the shell. This contrivance is certainly very beautiful. It is in fact a miniature sewer carrying off promptly and quickly the excrements as fast as they are made.

The heart, constricted at the middle like the former silk purses of the ladies, is shown in place. The constriction separates the auricle and the ventricle. And so even an oyster has three sets of circulating organs, the heart with its double set of functions, and the arteries and veins. And this little organ beats with regular pulsations. That little auricle receives the blood from the gills, and that tiny ventricle is the vital force-pump that propels it into the arteries. "From the capillary extremities of the arteries it collects again into the veins, circulates a second time through the respiratory organ, and returns to the heart as arterial blood." The color of the oyster's blood is a pale bluish white—in fact it may be called opaline. Our oyster, then, is not a heartless thing. If you open it with care and skill, as would the naturalist, you may see and count the throbbings of its tiny heart.

In its proper place is seen the liver, which is always a large organ in the mollusca, or so-called shell-fish. It is true that this organ in the oyster secretes bile, and doubtless in large quantities. It is not probable, however, that this organ, though large, ever performs a metaphorical function, for it is very doubtful whether the oyster ever gets up the amount of emotion necessary "to stir one's bile." To the fast liver this oyster-liver is every thing. The secret is just here: this secretion of the liver is the real appetizer of the feast. This oyster-bile is both gustatory and digestive. It excites the glands of the palate and the secretions of the stomach.

The part indicated by the word muscle is the portion through which the knife is passed when opening an oyster. In popular parlance it is sometimes called the "eye," and by some the "heart;" terms which, thus applied, are without meaning. It is the adductor muscle, and is the organ with which the oyster pulls-to its doors.

To sum up these considerations of the oyster's physiology, we see that, to the full extent of its necessities, it has distinctive sets of organs for the performance of the three classes of functions carried on in our own organization, namely, ingestion, respiration, and circulation.

The Oyster's Shell.—The toughest part of the oyster is the adductor muscle (Fig. 7). The office of this large, strong muscle is to pull-to and keep shut the great doors of the house. And a very curious bit of mechanism is subsidiary to this action. At the upper part of the cut is seen the hinge, a white spot with a dark curve below it. This dark curve is the hinge-ligament. It is a dark substance which fills up the pit or depression near the hinge. In the living animal it is wonderfully like gutta-percha—black, tough, and elastic. Let us attempt to explain its use to the oyster. Although this mollusk has a strong muscle with which to close its valves, it has not any with which to open them. Now, supposing we should take a lady's writing-desk, and, between the hinges at the back of the lids, should insert a piece of India-rubber, then should press down the lid, and turn the key; it is plain that the bolt of the lock now keeps the lid down, which could not be done simply by the weight of the lid, as before. Now, if we unlock the desk, up springs the lid, raised by the expansive force of the rubber at the hinges. This is precisely one of the functions of the hinge-ligament of the oyster. When the animal desires to shut up the valves, it contracts the great adductor muscle. When it needs to open them, it relaxes that muscle, and the valves open of themselves. Patrick's mishap was not merely amusing, regarded as a blunder, but even more so when viewed in this physiological light. He was told to go into the cellar and bring up some oysters in the shell; and his mistress gave him a strict charge not to bring any that were dead.

Fig. 7.—Organism of an Oyster.

Patrick brought up a tray full, and every bivalve upon it was gaping wide! In reply to the astonished look of his mistress he said: "Sure, mam, they must be alive, or how could they keep their mouths open?" "But, Patrick," urged the lady, "could you not tell the difference by the smell?" "And sure, mam, I was remarking that same to meself. But mightn't the others have bad breaths too, if they'd only open their mouths a bit?" Had the matter been pressed to an explanation, perhaps the mistress would have been as severely taxed as the servant to render a reason.

The growth of an oyster-shell is always at the edge. It is effected by the rim of the mantle, as a series of delicate tips assorting the lime which is held in solution in the sea-water, and most daintily laying in its proper place the invisible cement. The precise method of the operation is not, I think, understood. It seems to me that the process is not a direct one, but rather the result of another process. All can recollect the once-popular mackintosh, a sort of water-proof cloak. It was little else than ordinary cloth, with an insoluble substance infused into the spaces between the fibres of the fabric. Is it not likely that the oyster has a process of its own not very dissimilar?—that it deposits a delicate net-work of animal substance as the staple, and that this is soon filled in with carbonate of lime, taken in mechanically from the salt-water? And this same organ has, along its edge, a series of pigment-cells, from which it exudes the paint that decorates the shell. In this respect the American oyster is a very plain affair. That of Europe has more color on the shell, I think, as it is more corrugated in form, and of less size. Our own oysters, we believe, both in quality and size, excel all others. (For a group of European oysters, of ages varying from that of three days to that of one year, *see* Fig. 2.)

If the shell of an adult oyster be examined, it will appear to be a series of shells, lying or lapping upon each other like tiles. There is, however, a difference. The lap of the upper one is not merely on the upper end of the lower one, but also on the middle, thus leaving a margin nearly all round. So the uppermost layer is always the smallest, and the lowermost one is always the largest of the series. The oystermen call these laps "shoots"—each one represents a season's growth. Thus each "shoot" shows the precise size of the oyster at a given year of its life, while the sum of the entire series gives the exact number of years the creature has lived. This shows how often the logic of Nature runs in parallel lines; for it brings up the old maxim again, "Every one to his own trade." The botanist counts the season-rings in the bole of a tree. The jockey tells the age of the horse by its teeth. The drover sets down the age of the cattle he buys by counting the rings on the horns; and in like manner the oysterman comes to a judgment by the number of "shoots" on the bivalve's shell. But all these specialists alike err when giving judgment upon an individual that has reached extreme old age.

The capability of the univalve mollusks to repair the shell when broken has been long known and understood by naturalists. In respect to the bivalves not so much is known. The oyster has some wonderful things in the way of repairing its house after being broken into. A case is known to us in which an oyster was so badly fractured at the nib that a piece of shell about an inch wide was broken off, and the poor animal protruded. An oysterman, for experiment's sake, restored it to the water, and, to be sure, put it close by a pole driven into the bed. This was in the spring. In September it was taken up and examined, when lo! the ingenious little builder had thoroughly repaired all damages!

The Nervous System of an Oyster.—Physically unstrung, the good old lady thus gave expression to her sufferings: "O doctor, I'm getting so terribly nervous! I wish to goodness I'd no nerves at all, like an oyster!" An animal without nerves! One must go down very low in the scale of living things to find a creature enjoying such a dubious felicity. The amœba—a simple, gliding clot or molecule of living jelly—enjoys this singular distinction. It has no nerves. And of old time some of the philosophers even entertained no higher conception of the organization of the oyster. Nor was it any better with Seneca, the moralist, who so eloquently urged the practice of self-denial, and ascetic severity, and whose practical knowledge of the bivalve extended to the personal consumption of just one hundred at a time. These learned men knew nothing about amœbas, or they would surely have leaped to the conclusion that an oyster was an amœboid animal shut up in a shell. Science, however, that sturdy non-respecter of persons, while it has pulled some things down, has lifted others up. Some of this exaltation has fallen to the oyster. Its nervous system is shown to be a very beautiful affair, and might be made the basis of some startling hypotheses in philosophy. It seems that, in common with the other learned men of his day, Plato regarded the oyster as the typical know-nothing of creation, and so, under the process known as transmigration, he judicially consigned the soul of the ignorant man at death to the occupancy of an oyster. Only to think of it! That last half-dozen fat mollusks one took so unsuspectingly down from the half-shell were possessed of an equal number of low, unlettered rapscallions in the spiritual state! You don't believe it? Of course. Who does? And it doth appear that Mr. Plato had but little to do when he was thus billeting bad company upon respectable people. Indeed, has he not much to answer for? A philosopher tempting to sin! Is not the man who stirs the pun as bad as the punster? Even at the risk of incurring punitive consequences, it must be said

> That his metempsychosis
> A contemptible joke is!—

a sentiment which, for want of prose, had to be thrown into rhyme. But it is urged in extenuation that this great man was only chaffing some old Greek who liked oysters, and that we ought to look rather to the wheat of his philosophy.

It is not intended here to go the length of declaring for the oyster that it has the feelings of a gentleman; although in Figuier the Scotch oyster-dredgers (Fig. 6) are represented as singing at their toilsome work:

> "The herring it loves the merry moonlight,
> The mackerel it loves the wind;
> But the oyster it loves the dredger's song,
> For it comes of a gentle kind!"

Let us look closely at Fig. 8, which represents the nervous system of an oyster. It is necessary, in the study of the nerves of the invertebrate animals, to use the word *ganglion*, which means a knot of nerves. Really, it signifies a little brain, so that an insect or a mollusk may have several brains in different parts of its body. It should be remembered, also, that in anatomy the forward or anterior end of an oyster is the part containing the mouth, and that is up against the hinge, while the posterior part happens in this case to be near the opening, or, as the oystermen call it, the nib of the shell. At *b*, then, we see the large brain of the oyster called the posterior ganglion. We see, too, that it is surrounded by nerves running to other parts of the structure. There are two curved branches, marked *c c*, which connect this brain with two comb-like objects. These are the nerves of the branchiæ or gills. This brain, then, has direct control of the mechanism and functions of respiration. But it is noticeable that it is

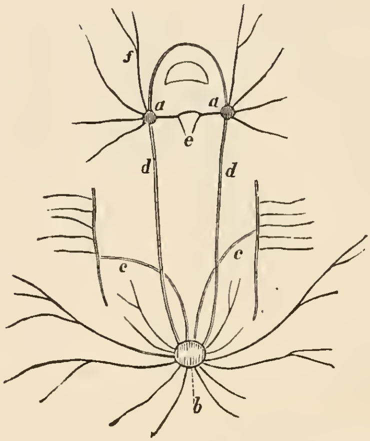

Fig. 8.—The Nervous System of an Oyster.

also connected with the entire system of the two nerve-lines, *d d*, which suggest the spinal cord of the vertebrates. And this double nerve-line crosses the two ganglia or little brains, *a a*, which are connected by the transverse nerve-branch *e;* thus the mouth, whose place is shown by the half-moon, is encircled by a nerve-ring, and this regulates the functions of ingestion. In those mollusks which travel, as do mussels and scallops, there is a ganglion or locomotive centre. Bearing this in mind, and the fact that the oyster does not have this ganglion, because it does not need it, not being a traveler at all, let us give the gist of Dr. Todd's remarks on the nervous system of the mollusca in general: "It affords a beautiful example of the complete analysis of the more complicated nervous system of the vertebrata. Have we not here distinctly marked out the cerebrum (the centre of volition and sensation), the medulla oblongata (the respiratory centre), and the cerebellum (the locomotive centre), as they occur in the higher vertebrata? And, in the aggregate of the chords by which the œsophageal ganglia communicate with the pedal and branchial ones, do we not see the analogue of at least a portion of the spinal cord, that portion which consists of afferent and efferent nerves to and from the brain?" It is plain, then, that, with a brain outfit of such a character and quantity, there must be something of a corresponding brain-force. In plain words, we mean that, possessing such a physiology, the oyster must sustain an analogous psychological relation. Organs imply functions. Pythagoras held that "animals have reason but no mind." Let us, then, see what sort of impressions an oyster can receive, and what kind of thinking it can do. If not too preposterous, we may even indicate its capacity to receive a modicum of education.

The adult oyster is eyeless, and of course blind. Yet it does without eyes that which we in its position could not do better with. It is affirmed that a bed of oysters has been seen to close by a precautionary impulse at the approach of a row-boat, even before the shadow of the approaching boat had reached them. Now, this is more than a blind man's distinguishing light from darkness. Is not that an exquisite sensitiveness which can thus note the faintest tint of shadow—the extremest margin of an oncoming obscuration?

Before the railroad days, our oyster-growers used early in the fall to canvass the villages on the Hudson River for orders, to be filled just before the river should be closed with ice. The meaning of this is that these men committed themselves to supply oysters in the shell, with the guarantee that the bivalves thus supplied should not die before their time came. The oysters were actually kept alive during the greater part of the long winter. The fat bivalves were handled with some care, and were spread on the cellar-floor, the round or lower side down, so as not to allow the liquor to escape. That such a life required a great change of capacity or habit in the bivalve is evident; and it needed a training, yes, an education, ere the oyster attained to such ability. And this was the way it was done: Beginning early in the fall, the cultivator of the oyster took up the fat bivalves from their bed where he had planted them, and laid them a little higher up on the shore, so that for a short time each day they were exposed out of the water. After a few days of this exposure by the retreating tide, they were moved a little higher still on the shore-line, which gave them a little longer exposure to the air at each low tide. And this process was continued, each remove resulting in a longer exposure. And with what results? Two very curious ones—inurement to exposure, and the inculcation of a provident habit of making preparation for the same. What! providence in an oyster? Yes, when he's educated. When accustomed to this treatment, ere the tide retires, the oyster takes a good full drink, and retains the same until the tide returns. Once, while waiting for the stage at a country hostelry, we overheard the following between two rustic practitioners at the bar: "Come, Swill, let's take a drink!" "Well, I don't know. Ain't dry myself. Hows'ever, guess I will take a drink, for fear I *might* get dry!" With better philosophy on their side, these educated oysters, twice in every twenty-four hours took their precautionary drink. The French method of oyster-training is much more laborious. The adult bivalves are carefully spread out *in* the water, and periodical lessons are given to each one individually. Each oyster on this occasion receives a tap, not with a ferule, but with a small iron instrument. This causes the bivalve to close tightly. Finally the last day comes with its last premonitory tap. Its education thus finished, it takes passage with its fellow-graduates for Paris. As a result of its education, it knows how to keep its mouth shut when it enters society!

Said one of the English commissioners at the great World's Fair, in respect of the American inventions on exhibition, "They show so much knowingness!" So we think of this oyster-training; the American practice shows a common-sense tact, not found in the French method. And, though in a vastly more ancient sense, the secret of keeping oysters alive in the winter is an American art. Connected with the inland deposits of oyster-shells, made by the former Indian tribes in New Jersey, the writer has discovered what he believes to be oyster-preserves, the evidence of pits in which the Indians stored the living bivalves for winter consumption, when the bays and rivers of New Jersey were frozen over. While unearthing this Indian *cache*, the thought occurred, "How knowing these ancient people must have been!"

The next article will give, in detail, the friends and companions of the oyster; its enemies, with their modes of attack, and the geographical area of this bivalve.

HERBERT SPENCER AND THE DOCTRINE OF EVOLUTION.[1]

THE change that has taken place in the world of thought within our own time, regarding the doctrine of Evolution, is something quite unprecedented in the history of progressive ideas. Twenty years ago that doctrine was almost universally scouted as a groundless and absurd speculation; now, it is admitted as an established principle by many of the ablest men of science, and is almost universally conceded to have a basis of truth, whatever form it may ultimately take. It is, moreover, beginning to exert a powerful influence in the investigation

[1] A Lecture delivered before the New York Liberal Club, June 5th, 1874, by E. L. Youmans.

of and mode of considering many subjects; while those who avow their belief in it are no longer pointed at as graceless reprobates or incorrigible fools.

With this general reversal of judgment regarding the doctrine, and from the prominence it has assumed as a matter of public criticism and discussion, there is naturally an increasing interest in the question of its origin and authorship; and also, as we might expect, a good deal of misapprehension about it. The name of Herbert Spencer has been long associated, in the public mind, with the idea of Evolution. And, while that idea was passing through what may be called its stage of execration, there was no hesitancy in according to him all the infamy of its paternity; but, when the infamy is to be changed to honor, by a kind of perverse consistency of injustice, there turns out to be a good deal less alacrity in making the revised award. That the system of doctrine put forth by Mr. Spencer would meet with strong opposition was inevitable. Representing the most advanced opinions, and disturbing widely-cherished beliefs at many points, it was natural that it should be strenuously resisted and unsparingly criticised. Nor is this to be regretted, as it is by conflict that truth is elicited; and those, who, after candid examination, hold his teachings to be erroneous and injurious, are certainly justified in condemning them. With such, at the present time, I have no controversy, but propose to deal with quite another class of critics. There are men of eminence, leaders of opinion, who neither know nor care much for what Mr. Spencer thinks or has done, but are quite ready with their verdicts about him; and, so long as it is not generally known to what an extent we are indebted to him for having originated and elaborated the greatest doctrine of the age, these superficial and careless deliverances from conspicuous men become very misleading and injurious. By many he is regarded as only a clever and versatile essayist, ambitious of writing upon every thing, and who has done something to popularize the views of Mr. Darwin and other scientists. For example, M. Taine, in a late Paris journal, says: "Mr. Spencer possesses the rare merit of having extended to the sum of phenomena—to the whole history of Nature and of mind—the two master-thoughts which, for the past thirty years, have been giving new form to the positive sciences; the one being Mayer and Joule's Conservation of Energy, the other Darwin's Natural Selection." Colonel Higginson says:[1] "Mr. Spencer has what Talleyrand calls the weakness of omniscience, and must write not alone on astronomy, metaphysics, and banking, but also on music, on dancing, on style." And again: "It seems rather absurd to attribute to him, as a scientific achievément, any vast enlargement or further generalization of the modern scientific doctrine of Evolution." To the same effect, Mr. Emerson, when recently called upon by a newspaper interviewer to furnish his opinions of great men, de-

[1] Estimating Spencer, in the *Friend of Progress*, 1864.

clared Mr. Spencer to be nothing better than a "stock-writer, who writes equally well upon all subjects."

These are not the circumspect and instructive utterances which we should look for from men of authority whose opinions are sought and are valued by the public; they are gross and inexcusable misrepresentations, and exemplify a style of criticism that is now so freely indulged in that it requires to be met, in the common interest of justice and truth. By their estimates of Mr. Spencer, the gentlemen quoted have raised the question of his position as a thinker, and the character and claims of his intellectual work. I follow their lead, and propose, on the present occasion, to bring forward some considerations which may help to a more trustworthy judgment upon the subject. Assuming the foregoing statements to be representative, it will be worth while to see what becomes of them under examination. My object will be, less to expound or to defend Mr. Spencer's views, than to trace his mental history, and the quality and extent of his labors, as disclosed by an analysis and review of his published writings.

And, first, let us glance at the general condition of thought in relation to the origination of things when he began its investigation. Character is tested by emergencies, as well in the world of ideas as in the world of action; and it is by his bearing in one of the great crises of our progressive knowledge of Nature that Mr. Spencer is to be measured.

Down to the early part of the present century it had generally been believed that this world, with all that it contains, was suddenly called into existence but a few thousand years ago in much the same condition as we now see it. Throughout Christendom it was held, with the earnestness of religious conviction, that the universe was a Divine manufacture, made out of nothing in a week, and set at once to running in all its present perfection. This doctrine was something more than a mere item of faith; it was a complete theory of the method of origin of natural things, and it gave shape to a whole body of science, philosophy, and common opinion, which was interpreted in accordance with this theory. The problem of *origins* was thus authoritatively solved, and life, mind, man, and all Nature, were studied under the hypothesis of their late and sudden production.

But it was difficult to inquire into the existing order of Nature without tracing it backward. Modern science was long restrained from this procedure by the power of traditional beliefs, but the force of facts and reasoning at length proved too strong for these beliefs, and it was demonstrated that the prevailing notion concerning the recent origin of the world was not true. Overwhelming evidence was found that the universe did not come into existence in the condition in which we now see it, nor in any thing like that condition, but that the present order of things is the outcome of a vast series of changes running back to an indefinite and incalculable antiquity. It was proved that the present forms and distributions of mountains, valleys, continents, and oceans, are but the final terms of a stupendous course of transformations to which the crust of the earth has been subjected. It was also established that life has stretched back for untold millions of years; that multitudes of its forms arose and perished in a determinate succession, while the last appearing are highest in grade, as if by some principle of order and progression.

It is obvious that one of the great epochs of thought had now been reached; for the point of view from which natural things are to be regarded was fundamentally and forever altered. But, as it is impossible to escape at once and completely from the dominion of old ideas, the full import of the position was far from being recognized, and different classes of the thinking world were naturally very differently affected by the new discoveries. To the mass of people who inherit their opinions and rarely inquire into the grounds upon which they rest, the changed view was of no moment; nor had the geological revelations much interest to the literary classes beyond that of bare curiosity about strange and remote speculations. To the theologians, however, the step that had been taken was of grave concern. They were the proprietors of the old view; they claimed for it supernatural authority, and strenuously maintained that its subversion would be the subversion of religion itself. They maintained, moreover, that the controversy involved the very existence of God. The most familiar conception of the Deity was that of a *Creator*, and *creation* was held to mean the grand six-day drama of calling the universe into existence; while this transcendent display of power had always been devoutly held as alike the exemplification and the proof of the Divine attributes. How deep and tenacious was the old error is shown by the fact that, although it has been completely exploded, although the immeasurable antiquity of the earth and the progressive order of its life have been demonstrated and admitted by all intelligent people, yet the pulpit still clings to the old conceptions, and the traditional view is that which generally prevails among the multitude.

To men of science the new position was, of course, in the highest degree, important. It was stated by Prof. Sedgwick, in an anniversary address to the Geological Society of London, in 1831, as follows: "We have a series of proofs the most emphatic and convincing that the approach to the present system of things has been gradual, and that there has been a progressive development of organic structure subservient to the purposes of life." The traditional explanation of the origin of the world, and all that belongs to it, being thus discredited, it only remained to seek another explanation: if it has not been done one way, how has it been done? was the inevitable question. One might suppose that the effect of the utter break-down of the old hypothesis would have been to relegate the whole question to the sphere of science, but this was far from being done. The preternatural solution had failed, but its only logical alternative, a natural solution, or the thorough investigation of the subject on principles of causation, was not adopted or urged. The geologists occupied themselves in extending observations and accumulating facts rather than in working out any comprehensive scientific or philosophical principles from the new point of view. The result was a kind of tacit compromise between the contending parties—the theologians conceding the vast antiquity of the earth, and the geologists conceding preternatural intervention in the regular on-working of the scheme; so that, in place of one mighty miracle of creation occurring a few thousand years ago, there was substituted the idea of hundreds of thousands of separate miracles of special creation scattered all along the geological ages, to account for the phenomena of terrestrial life. Two systems of agencies—natural and supernatural—were thus invoked to explain the production of effects. What it now concerns us to note is, that the subject had not yet been brought into the domain of science. One portion of it was still held to be above Nature, and therefore inaccessible to rational inquiry; while that part of the problem which was withheld from science was really the key to the whole situation. Under the new view, the question of the origin of living forms, or of the action of natural agencies in their production, was as completely barred to science as it had formerly been under the literal Mosaic interpretation; and, as questions of origin were thus virtually interdicted, the old traditional opinions regarding the genesis of the present constitution of things remained in full force.

It is in relation to this great crisis in the course of advancing thought that Herbert Spencer is to be regarded. Like many others, he assumed, at the outset, that the study of the whole phenomenal sphere of Nature belongs to science; but he may claim the honor of being the first to discern the full significance of the new intellectual position. It had been proved that a vast course of orderly changes in the past has led up to the present, and is leading on to the future: Mr. Spencer saw that it was of transcendent moment that the laws of these changes be determined. If natural agencies have been at work in vast periods of time to bring about the present condition of things, he perceived that a new set of problems of immense range and importance is open to inquiry, the effect of which must be to work an extensive revolution of ideas. It was apparent to him that the hitherto forbidden question as to how things have originated had at length come to be the supreme question. When the conception that the present order had been called into being at once and in all its completeness was found to be no longer defensible, it was claimed that it makes no difference how it originated—that the existing system is the same whatever may have been its source. Mr. Spencer saw, on the contrary, that the question how things have been caused is fundamental; and that we can have no real understanding of what they are, without first knowing how they came to be what they are. Starting from the point of view made probable by the astronomers, and demonstrated by the geologists, that, in the mighty past, Nature has conformed to one system of laws; and assuming that the existing order, at any time, is to be regarded as growing out of a preëxisting order, Mr. Spencer saw that nothing remained for science but to consider all the contents of Nature from the same point of view. It was, therefore, apparent that life, mind, man, science, art, language, morality, society, government, and institutions, are things that have undergone a gradual and continuous unfolding, and can be explained in no other way than by a theory of growth and derivation. It is not claimed that Mr. Spencer was the first to adopt this mode of inquiry in relation to special subjects, but that he was the first to grasp it as a general method, the first to see that it must give us a new view of human nature, a new science of mind, a new theory of society—all as parts of one coherent body of thought, and that he was, moreover, the first to work out a comprehensive philosophical system from this point of inquiry, or on the basis of the principle of Evolution. In a word, I maintain Spencer's position as a thinker to be this: taking a view of Nature that was not only generally discredited, but was virtually foreclosed to research, he has done more than any other man to make it the starting-point of a new era of knowledge.

For the proof of this I now appeal to his works. Let us trace the rise and development of the conception of Evolution in his own mind, observe how he was led to it, and how he pursued it, and see how completely it pervades and unifies his entire intellectual career. Various explanatory details that follow, I have obtained from conversations with Mr. Spencer himself; but the essential facts of the statement are derived from his works, and may be easily verified by any who choose to take the trouble of doing so.

Mr. Spencer is not a scholar in the current acceptation of the term; that is, he has not mastered the curriculum of any university. Unbiassed by the traditions of culture, his early studies were in the sciences. Born in a sphere of life which made a vocation necessary, he was educated as a civil-engineer, and up to 1842, when he was twenty-two years of age, he had written nothing but professional papers published in the *Civil Engineer and Architects' Journal.* But he had always been keenly interested in political and social questions, which he had almost daily heard discussed by his father and uncles. In the summer of 1842 he began to contribute a series of letters to a weekly newspaper, the *Nonconformist*, under the title of "The Proper Sphere of Government." It was the main object of these letters to show that the functions of government should be limited to the protection of life, property, and social order, leaving all other social ends to be achieved by individual activities. But, beyond this main conception, it was implied throughout that there are such things as laws of social development, natural processes of rectification in society, and an adaptation of man to the conditions of social life. The scientific point of view was thus early assumed, and society was regarded not as a manufacture but as a growth. These letters were revised and published in a pamphlet in 1843.

The argument, however, was unsatisfactory from its want of depth and scientific precision, and Mr. Spencer decided in 1846 to write a work in which the leading doctrine of his pamphlet should be affiliated upon general moral principles. By reading various books upon moral philosophy he had become dissatisfied with the basis of morality which they adopt; and it became clear to him that the question of the proper sphere of government could be dealt with only by tracing ethical principles to their roots. The plan of this work was formed while Mr. Spencer was still a civil-engineer; and it was commenced in 1848, before he abandoned engineering and accepted the position of sub-editor of the *Economist*. It was issued, under the title of "Social Statics," at the close of 1850. In this work various developments of the ideas contained in the pamphlet above named are noticeable. It will be seen that the conception that there is an adaptation going on between human nature and the social state has become dominant. There is the idea that all social evils result from the want of this adaptation, and are in process of disappearance as the adaptation progresses. There is the notion that all morality consists in conformity to such principles of conduct as allow of the life of each individual being fulfilled, to the uttermost, consistently with the fulfillment of the lives of other individuals; and that the vital activities of the social human being are gradually being moulded into such form that they may be realized to the uttermost without mutual hindrance. Social progress is in fact viewed as a natural evolution, in which human beings are moulded into fitness for the social state, and society adjusted into fitness for the natures of men—the units and the aggregate perpetually acting and reacting, until equilibrium is reached. There is recognized not only the process of continual direct adaptation of men to their circumstances by the inherited modifications of habit, but there is also recognized the process of the dying out of the unfit and the survival of the fit. And these changes are regarded as parts of a process of general evolution, tacitly affirmed as running through all animate Nature, tending ever to produce a more complete and self-sufficing individuality, and ending in the highest type of man as the most complete individual.

After finishing "Social Statics" Mr. Spencer's thoughts were more strongly attracted in the directions of biology and psychology—sciences which he saw were most intimately related with the progress of social questions; and one result reached at this time was significant. As he states in the essay on the "Laws of Organic Form," published in 1859 in the *Medico-Chirurgical Review*, it was in the autumn of 1851, during a country ramble with Mr. George Henry Lewes, that the germinal idea of that essay was reached. This idea, that the forms of organisms, in respect of the different kinds of their symmetry and asymmetry, are caused by their different relations to surrounding incident forces, implies a general recognition of the doctrine of Evolution, a further extension of the doctrine of adaptation, and a foreshadowing of the theory of life as a correspondence between inner and outer actions.

In 1852 Mr. Spencer published in the *Westminster Review* the "Theory of Population deduced from the General Law of Animal Fertility," setting forth an important principle which he says that he had entertained as far back as 1847. Here also the general belief in Evolution was tacitly expressed; the theory being that, in proportion as the power of maintaining individual life is small, the power of multiplication is great; that along with increased evolution of the individual there goes decreased power of reproduction; that the one change is the cause of the other; that in man as in all other creatures the advance toward a higher type will be accompanied by a decrease of fertility; and that there will be eventually reached an approximate equilibrium between the rate of mortality and the rate of multiplication. Toward the close of this argument there is a clear recognition of the important fact that excessive multiplication and the consequent struggle for existence cause this advance to a higher type. It is there argued that "only those who do advance under it eventually *survive*," and that these "must be the *select* of their generation." That which, as he subsequently stated in the "Principles of Biology," Mr. Spencer failed to recognize at this time (1852) was the effect of these influences in producing the *diversities* of living forms; that is, he did not then perceive the coöperation of these actions of the struggle for existence and the survival of the fittest with the tendency to variation which organisms exhibit. He saw only the power of these processes to produce a higher form of the same type, and did not recognize how they may give rise to divergencies and consequent differentiations of species, and eventually of genera, orders, and classes.

Early in 1852, Mr. Spencer also printed a brief essay in the *Leader*, on "The Development Hypothesis," in which some of the now current reasons for believing in the gradual evolution of all organisms, including man, are indicated. To this paper Mr. Darwin refers in the introductory sketch of the previous course of research on the subject of development, which he prefixed to the "Origin of Species." In this essay, however, *direct* adaptation to the conditions of existence is the only process recognized.

In October of the same year (1852), Mr. Spencer published an essay in the *Westminster Review*, on the "Philosophy of Style," in which, though the subject appears so remote, there are traceable some of the cardinal ideas now indicated, and others that were afterward developed. The subject was treated from a dynamical point of view, and, as Mr. Lewes remarks in his essays on the "Principles of Success in Literature," it offers the only scientific exposition of the problem of style that we have. The general theory set forth is, that effectiveness of style depends on a choice of words and forms of sentence offering the *least resistance* to thought in the mind of the reader or hearer—a foreshadowing of the general law of the "line of least resistance" as applied to the interpretation of psychological phenomena, as well as phenomena in general. Moreover, at the close of the essay, there is a reference to the law of Evolution in its application to speech—there is a recognition of the fact that "increasing heterogeneity" has been the characteristic of advance in this as in other things, and that a highly-evolved style will "answer to the description of all highly-organized products, both of man and of Nature; it will be, not a series of like parts simply placed in juxtaposition, but one whole made up of unlike parts that are mutually dependent." Here, as early as 1852, there are recognized in one of the highest spheres both the process of differentiation and the process of integration—the two radical conceptions of Evolution.

In July of the next year (1853), Mr. Spencer's continued interest in the question of the functions of the state led him to write the essay on "Over-Legislation" in the *Westminster Review;* and here, as in "Social Statics," the conception of society as a growth, under the operation of natural laws, is predominant.

The critical perusal of Mr. Spencer's works shows that this was a very important period in the development of his views. The reading of Mr. Mill's "Logic," along with some other philosophical works, had led him to the elaboration of certain opinions at variance with those of Mr. Mill on the question of our ultimate beliefs, and those he published in the *Westminster Review*, under the title of "The Universal Postulate" (1853). The inquiries thus commenced, together with those respecting the nature of the moral feelings, and those concerning life and development, bodily and mental, into which he had been led, both by "Social Statics" and the "Theory of Population," prepared the way for the "Principles of Psychology." Some of the fundamental conceptions contained in this remarkable work now began to take shape in his mind. Other ideas connected with the subject began also to form in his mind, an example of which is furnished by the essay on "Manners and Fashion," published in the *Westminster Review* (April, 1854). Various traits of the general doctrine of Evolution are here clearly marked out in their relations to social progress. It is shown that the various forms of restraint exercised over men in society—political, ecclesiastical, and ceremonial—are all divergent unfoldings of one original form, and that the development of social structure, in these as in other directions, takes place by gradual and continuous differentiations, "in conformity with the laws of Evolution of all organized bodies."

Mr. Spencer was at the same time engaged in working out his view in a different sphere, the essay on the "Genesis of Science" being contributed to the *British Quarterly Review* in July, 1854. This was primarily called forth by Miss Martineau's "Abridgment of Comte," then just issued, and was in part devoted to the refutation of the French philosopher's views respecting the classification of the sciences. But it became the occasion for a further development of the doctrine of Evolution in its relation to intellectual progress. The whole genesis of science is there traced out historically under the aspect of a body of truths, which, while they became differentiated into different sciences, became at the same time more and more integrated, or mutually dependent, so as eventually to form "an organism of the sciences." There is, besides, a recognition of the gradual increase in definiteness that accompanies this increase in heterogeneity and in coherence.

It was at this time that Mr. Spencer's views on psychology began to assume the character of a system—the conception of intellectual progress now reached being combined with the ideas of life previously arrived at, in the development of a psychological theory. The essay on the "Art of Education,"[1] published in the *North British Review* (May, 1854), assisted in the further development of these ideas. In that essay the conception of the progress of the mind during education is treated in harmony with the conception of mental Evolution at large. Methods are considered in relation to the law of development of the faculties, as it takes place naturally. Education is regarded as rightly carried on only when it aids the process of self-development; and it is urged that the course in all cases followed should be from the simple to the complex, from the indefinite to the definite, from the concrete to the abstract, and from the empirical to the rational.

Having reached this stage in the unfolding of his ideas, Mr. Spencer began the writing of the "Principles of Psychology" in August, 1854. This is a work of great originality, and is important as marking the advance of Mr. Spencer's philosophical views at the time of its preparation. The whole subject of mind is dealt with from the Evolution point of view. The idea which runs through "Social Statics," that there is ever going on an adaptation between living beings and their circumstances, now took on a profounder significance. The *relation* between the organism and its environing conditions was found to be involved in the very nature of life; and the idea of adaptation was developed into the conception that life itself "is the definite combination of heterogeneous changes, both simultaneous and successive in *correspondence* with external coexistences and sequences." It is argued that the degree of life varies with the degree of correspondence, and that all mental phenomena ought to be interpreted in terms

[1] Republished in his little work on "Education," under the title of "Intellectual Education."

of this correspondence. Commencing with the lowest types of life, Mr. Spencer, in successive chapters, traces up this relation of correspondence as extending in spaee and time, as increasing in specialty, in generality, and in complexity. It is also shown that the correspondence progresses from a more homogeneous to a more heterogeneous form, and that it becomes gradually more integrated—the terms here employed, in respect to the Evolution of mind, being the terms subsequently used in treating of Evolution in general. In the fourth part of the work, under the title of "Special Synthesis," the Evolution is traced out under its eoncrete form from reflex action up through instinct, memory, reason, feelings, and the will. Mr. Spencer here distinctly avowed his belief that "Life, in its multitudinous and infinitely varied embodiments, has arisen out of the lowest and simplest beginnings, by steps as gradual as those which evolve a homogeneous microscopic germ into a complex organism"—dissent being, at the same time, expressed from that version of the doctrine put forth by the author of the "Vestiges of the Natural History of Creation." It was, moreover, shown by subjective analysis how intelligence may be resolved, step by step, from its most complex into its simplest elements; and it was also proved that there is "unity of composition" throughout, and that thus mental structure, contemplated internally, harmonizes with the doctrine of Evolution.

It was at this time (1854), as I have been informed by Mr. Spencer, when he had been at work upon the "Principles of Psychology" not more than two months, that the general conception of Evolution in its causes and extent, as well as its processes, was arrived at. He had somewhat earlier conceived of it as universally a transformation from the homogeneous into the heterogeneous. This kind of change which Von Baer had shown to take place in every individual organism, as it develops, Mr. Spencer had already traced out as taking place in the progress of social arrangements, in the development of the sciences, and now in the Evolution of mind in general from the lower forms to the higher. And the generalization soon extended itself so as to embrace the transformations undergone by all things inanimate as well as animate. This universal extension of the idea led rapidly to the conception of a universal cause necessitating it. In the autumn of 1854, Mr. Spencer proposed to the editor of the *Westminster Review* to write an article upon the subject under the title of "The Cause of all Progress," which was objected to as being too assuming. The article was, however, at that time agreed upon, with the understanding that it should be written as soon as the "Principles of Psychology" was finished. The agreement was doomed to be defeated, however, so far as the date was concerned, for, along with the completion of the "Psychology," in July, 1855, there came a nervous break-down, which incapacitated Mr. Spencer for labor during a period of eighteen months—the whole work having been written in less than a year.

We may here note Mr. Spencer's advanced position in dealing with this subject. While yet the notion of Evolution as a process of Nature was as vague and speculative as it had been in the time of Anaximander and Democritus, he had grasped the problem in its universality and its causes, and had successfully applied it to one of the most difficult and important of the sciences. He had traced the operation of the law in the sphere of mind, and placed that study upon a new basis. The conviction is now entertained by many that the "Principles of Psychology," by Spencer, in 1855, is one of the most original and masterly scientific treatises of the present century, if, indeed, it be not the most fruitful contribution to scientific thought that has appeared since the "Principia" of Newton.[1] For thousands of years, from Plato to Hamilton, the world's ablest thinkers had been engaged in the effort to elucidate the phenomena of mind; Herbert Spencer took up the question by a method first rendered possible by modern science, and made a new epoch in its progress. From this time forward, mental philosophy, so called, could not confine itself to introspection of the adult human consciousness. The philosophy of mind must deal with the whole range of psychical phenomena, must deal with them as manifestations of organic life, must deal with them genetically, and show how mind is constituted in connection with the experience of the past. In short, as it now begins to be widely recognized, Mr. Spencer has placed the science of mind firmly upon the ground of Evolution. Like all productions that are at the same time new and profound, and go athwart the course of long tradition, there were but few that appreciated his book, a single small edition more than sufficing to meet the wants of the public for a dozen years. But it began at once to tell upon advanced thinkers, and its influence was soon widely discerned in the best literature of the subject. The man who stood, perhaps, highest in England as a psychologist, Mr. John Stuart Mill, remarked in one of his books, that "it is one of the finest examples we possess of the psychological method in its full power;" and, as I am aware, after carefully rereading it some years later, he declared that his already high opinion of the work had been raised

[1] This association of the name of Spencer with Newton, let it be remembered, does not rest upon the authority of the present writer; recent discussions of the subject in the highest quarters are full of it. The *Saturday Review* says, "Since Newton there has not in England been a philosopher of more remarkable speculative and systematizing talent than (spite of some errors and some narrowness) Mr. Herbert Spencer." An able writer in the *Quarterly Review*, in treating of Mr. Spencer's remarkable power of binding together different and distant subjects of thought by the principle of Evolution, remarks: "The two deepest scientific principles now known of all those relating to material things are the Law of Gravitation and the Law of Evolution." The eminent Professor of Logic in Owens College, Manchester, Mr. W. Stanley Jevons, in his recent treatise entitled "The Principles of Science, a Treatise on Logic and Scientific Method," says, "I question whether any scientific works which have appeared, since the 'Principia' of Newton, are comparable in importance with those of Darwin and Spencer, revolutionizing as they do all our views of the origin of bodily, mental, moral, and social phenomena."

still more—which he recognized as due to the progress of his own mind.

The article "Progress, its Law and Cause," projected, as we have seen, in 1854, was written early in 1857. In the first half of it the transformation of the homogeneous into the heterogeneous is traced throughout all orders of phenomena; in the second half the principle of transformation is deduced from the law of the multiplication of effects. In this essay, moreover, there is indicated the application of the general law of Evolution to the production of species. It is shown that there "would not be a substitution of a thousand more or less modified species for the thousand original species; but, in place of the thousand modified species, there would arise several thousand species, or varieties, or changed forms;" and that "each original race of organisms would become the root from which diverged several races differing more or less from it and from each other." It is further argued that the new relations in which animals would be placed toward one another would initiate further differences of habit and consequent modifications, and that "there must arise, not simply a tendency toward the differentiations of each race of organisms into several races, but also a tendency to the occasional production of a somewhat higher organism." The case of the divergent varieties of man, some of them higher than others, caused in this same manner, is given in illustration. Throughout the argument there is a tacit implication that, as a consequence of the cause of Evolution, the production of species will go on, not in ascending linear series, but by perpetual divergence and redivergence—branching and again branching. The general conception, however, differs from that of Mr. Darwin in this—that adaptation and readaptation to continually-changing conditions is the only process recognized—there is no recognition of "spontaneous variations," and the natural selection of those that are favorable.

During the summer of 1857 Mr. Spencer wrote the "Origin and Function of Music," published in *Fraser's Magazine* for October. Like nearly all of his other writings, this interesting article is dominated by the idea of Evolution. The general law of nervo-motor action in all animals is shown to furnish an explanation of the tones and cadences of emotional speech; and it is pointed out that from these music is evolved by simple exaltation of all the distinctive traits, and carrying them out into ideal combination. A further step was taken, the same year, in the development of the doctrine of Evolution, which is indicated in the article entitled "Transcendental Physiology." It was there explained that the multiplication of effects was not the only cause of the universal change from homogeneity to heterogeneity, but that there was an antecedent principle to be recognized, viz., the *Instability of the Homogeneous*. The physiological illustrations of the law are mainly dwelt upon, though its other applications are indicated.

In October of the same year, the essay on "Representative Government—what is it good for?" appeared in the *Westminster Review*. The law of progress is here applied to the interpretation of state functions, and it is stated that the specialization of offices, "as exhibited in the Evolution of living creatures, and as exhibited in the Evolution of societies," holds throughout; that "the governmental part of the body politic exemplifies this truth equally with its other parts." In January, 1858, the essay on "State Tamperings with Money and Banks" appeared in the same periodical. The general doctrine of the limitations of state functions is there reaffirmed, with further illustration of the mischiefs that arise from traversing the normal laws of life; and it is contended that "the ultimate result of shielding men from the effects of folly is to fill the world with fools"—an indirect way of asserting the beneficial effects of the survival of the fittest.

In April, 1858, Mr. Spencer published an essay on "Moral Education," in the *British Quarterly Review*, and throughout the argument every thing is again regarded from the Evolution point of view. The general truth insisted upon is, that the natural rewards and restraints of conduct are those which are most appropriate and effectual in modifying character. The principle contended for is, that the moral education of every child should be regarded as an adaptation of its nature to the circumstances of life; and that to become adapted to these circumstances it must be allowed to come in contact with them; must be allowed to suffer the pains and obtain the pleasures which do in the order of Nature follow certain kinds of action. There is here, in fact, applied to actual life, the general conception of the nature of life, previously inculcated in the "Principles of Psychology"—a correspondence between the inner and the outer actions that becomes great in proportion as the converse with outer actions through experience becomes extended.

The essay on the "Nebular Hypothesis" was published in the *Westminster Review* for July, 1858. The opinion was then almost universally held that the nebular hypothesis had been exploded, and the obvious bearing of the question upon the theory of Evolution induced Mr. Spencer to take it up. The conclusions that had been drawn from observations with Lord Rosse's telescope, that the nebular hypothesis had been invalidated, were shown to be erroneous; and the position taken, that the nebulæ could not be (as they were then supposed to be) remote sidereal systems, has been since verified. Spectrum analysis has, in fact, proved what Mr. Spencer then maintained, that there are many nebulæ composed of gaseous matter. To the various indications of the nebular origin of our own solar system commonly given, others were added which had not been previously recognized, while the view that Mr. Spencer took of the constitution of the solar atmosphere has since been also verified by spectrum analysis.

In October, 1858, he published in the *Medico-Chirurgical Review* a criticism on Prof. Owen's "Archetype and Homologies of the Vertebrate Skeleton," which was written in furtherance of the doctrine of Evolution, and to show that the structural peculiarities which are not accounted for on the theory of an archetypal vertebra, are accounted for on the hypothesis of development. In January of the next year, there appeared in the same review a paper on "The Laws of Organic Form," already referred to, the germ of which dated back to 1851, and which was a further elucidation of the doctrine of Evolution, by showing the direct action of incident forces in modifying the forms of organisms and their parts. In April, 1859, appeared in the *British Quarterly Review* an article on "Physical Education," in which the bearing of biological principles upon the management of children in respect to their bodily development is considered. It insists upon the normal course of unfolding, *versus* those hindrances to it which ordinary school regulations impose; it asserts the worth of the bodily appetites and impulses in children, which are commonly so much thwarted; and contends that during this earlier portion of life, in which the main thing to be done is to grow and develop, our educational system is too exacting—"it makes the juvenile life far more like the adult life than it should be." The essay "What Knowledge is of most Worth" was printed in the *Westminster Review* for July, 1859. This argument is familiar to the public, as it has been many times republished, but what is here most worthy of note is that, in criticising the current study of history, it defines with great distinctness the plan of the "Descriptive Sociology," the first divisions of which are now just published, and form the comprehensive and systematic data upon which the Principles of Sociology are to be based.

An argument on "Illogical Geology" was contributed in July, 1859, to the *Universal Review*, which, although nominally a criticism of Hugh Miller, was really an attack upon the prevalent geological doctrine which asserted simultaneity in the systems of strata in different parts of the earth. His view, which was at that time heresy, is now coming into general recognition. In the *Medico-Chirurgical Review* for January, 1860, Mr. Spencer published a criticism on Prof. Bain's work, "The Emotions and the Will," designed to show that the emotions cannot be properly understood and classified without studying them from the point of view of Evolution, and tracing them up through their increasing complications from lower types of animals to higher. The essay on the "Social Organism" appeared at the same time in the *Westminster Review*, in which it was maintained that society, consisting of an organized aggregate, follows the same course of Evolution with all other organized aggregates—increasing in mass and showing a higher integration not only in this respect but also in its growing solidarity; becoming more and more heterogeneous in all its structures and more and more definite in all its differentiations. The

"Physiology of Laughter," which appeared the same year in *Macmillan's Magazine*, was a contribution to nervous dynamics from the point of view that had been taken in the "Principles of Psychology." Even in Mr. Spencer's discussion of "Parliamentary Reforms, their Dangers and Safeguards" (*Westminster Review*, 1860), the question is dealt with on scientific grounds ultimately referring to the doctrine of Evolution. It was its general purpose to show that the basis of political power can be safely extended only in proportion as political function is more and more restricted. It was maintained in an earlier essay that representative government is the best possible for that which is the essential office of a government—the maintenance of those social conditions under which every citizen can carry on securely and without hindrance the pursuits of life—and that it is the worst possible for other purposes. And in continuation of this argument it was here contended that further extension of popular power should be accompanied by a further restriction of state duty—a further specialization of state function. In the essay on "Prison Ethics," contributed to the *British Quarterly Review* in July, 1860, a special question is very ably dealt with in the light of those biological, psychological, and sociological principles which belong to the Evolution philosophy. The principle of moral Evolution is asserted and the concomitant unfolding of higher and better modes of dealing with criminals.

We have now passed in rapid review the intellectual work of Mr. Spencer for nearly twenty years, and have shown that, though apparently miscellaneous, it was, in reality, of a highly methodical character. Though treating of many subjects, he was steadily engaged with an extensive problem which was resolved, step by step, through the successive discovery of those processes and principles of Nature which constitute the general law of Evolution. Beginning in 1842 with the vague conception of a social progress, he subjected this idea to systematic scientific analysis, gave it gradually a more definite and comprehensive form, propounded the principles of heredity and adaptation in their social applications, recognized the working of the principle of selection in the case of human beings, and affiliated the conception of social progress upon the more general principle of Evolution governing all animate Nature. Seizing the idea of increasing heterogeneity in organic growth, he gradually extended it in various directions. When the great conception, thus pursued, had grown into a clear, coherent, and well-defined doctrine, he took up the subject of psychology, and, combining the principle of differentiation with that of integration, he placed the interpretation of mental phenomena upon the basis of Evolution. We have seen that two years after the publication of the "Psychology," or in 1857, Mr. Spencer had arrived at the law of Evolution as a universal principle of Nature, and worked it out both inductively as a process of increasing heterogeneity and deductively from the principles of the instability of the homogeneous and the multiplication of effects. How far Mr. Spencer was here in advance of all other workers in this field will appear, when we consider that the doctrine of Evolution, as it now stands, was thus, in its universality, and in its chief outlines, announced by him two years before the appearance of Mr. Darwin's "Origin of Species."

A principle of natural changes more universal than any other known, applicable to all orders of phenomena, and so deep as to involve the very origin of things, having thus been established, the final step remained to be taken, which was, to give it the same ruling place in the world of thought and of knowledge that it has in the world of fact and of Nature. A principle running through all spheres of phenomena must have the highest value for determining scientific relations; and a genetic law of natural things must necessarily form the deepest root of the philosophy of natural things. It was in 1858, as Mr. Spencer informs me, while writing the article on the "Nebular Hypothesis," that the doctrine of Evolution presented itself as the basis of a general system under which all orders of concrete phenomena should be generalized. Already the conception had been traced out in its applications to astronomy, geology, biology, psychology, as well as all the various super-organic products of social activity; and it began to appear both possible and necessary that all these various concrete sciences should be dealt with in detail from the Evolution point of view. By such treatment, and by that only, did it appear practicable to bring them into relation so as to form a coherent body of scientific truth—a System of Philosophy.

It is proper in this place to state that, in contemplating the execution of so comprehensive a work, the first difficulty that arose was a pecuniary one. Mr. Spencer had frittered away the greater part of what little he possessed in writing and publishing books that did not pay their expenses, and a period of eighteen months of ill-health and enforced idleness consequent on the writing of one of them had further diminished his resources. His state of health was still such that he could work, at the outside, but three hours a day, and very frequently not even that, so that what little he could do in the shape of writing for periodicals, even though tolerably paid for it, did not suffice to meet the expenses of a very economical bachelor-life. How, then, could he reasonably hope to prosecute a scheme elaborating the doctrine of Evolution throughout all its departments in the way contemplated—a scheme that would involve an enormous amount of thought, labor, and inquiry, and which seemed very unlikely to bring any pecuniary return, even if it paid its expenses? Unable to see any solution of the difficulty, Mr. Spencer wrote, in July, 1858, to Mr. John Stuart Mill, explaining his project, and asking whether he thought that in the administration for India, in which Mr. Mill held office, there was likely to be any post, rather of trust than of much work, which would leave him leisure enough for the execution of his scheme. Mr. Mill replied sympathetically, but nothing turned out to be available. In despair of any other possibility, Mr. Spencer afterward extended his application to the Government; being reënforced by the influence of various leading scientific men, who expressed themselves strongly respecting the importance of giving him the opportunity he wished. A peculiar difficulty, however, here arose. Mr. Spencer is a very impracticable man—that is, he undertakes to conform his conduct to right principles, and his decided views as to the proper functions of government put an interdict upon the far greater number of posts that might otherwise be fit. Among the few that he could accept, the greater part were not available because they did not offer the requisite leisure. One position became vacant which he might have accepted, that of Inspector of Prisons, I think; but, though effort in his behalf was made by Lord Stanley (now Lord Derby, who was familiar with Mr. Spencer's works and entertained the matter with interest), the claims of party were too strong, and no arrangement was made.

Other plans failing, Mr. Spencer decided to adopt the plan of subscription, and issue his "System of Philosophy" in a serial form. A prospectus of that system was issued in March, 1860, which outlined the contents of the successive parts. The first installment of the work was issued in October, 1860, and the commencing volume, "First Principles," was published in June, 1862.

In this work the general doctrine of Evolution is presented in a greatly developed form; and the author's former views are not only combined but extended. The law of Von Baer, which formulates organic development as a transformation of the homogeneous into the heterogeneous, Mr. Spencer had previously shown to hold of all aggregates whatever—of the universe as a whole and of all its component parts. But, in "First Principles," it was shown that this universal transformation is a change from *indefinite* homogeneity to *definite* heterogeneity; and it is pointed out that only when the increasing multiformity is joined with increasing definiteness, does it constitute Evolution as distinguished from other changes that are like it in respect of increasing heterogeneity. This is, however, a much more important development of the principle. This change from the indefinite to the definite is shown to be the accompaniment of a more essential change from the incoherent to the coherent. Throughout all aggregates of all orders it is proved that there goes on a process of *integration*. This process is shown to hold alike in the growth and consolidation of each aggregate as well as in the growth and consolidation of its differentiated parts. The law of the instability of the homogeneous is also more elaborately traced out. Under the head of the *principle of segregation* it is, moreover, shown that the universal process by which, in aggregates of mixed units, the units of like kinds tend to gather together, and the units of unlike kinds to separate, everywhere coöperates in aiding Evolution. Yet a further universal law is recognized and developed—the law of equilibration. The question is asked, "Can these changes which constitute Evolution continue without limit?" and the answer given is that they cannot; but that they universally tend in each aggregate toward a final state of quiescence, in which all the forces at work have reached a state of balance. Like the other universal processes, that of equilibration is traced out in all divisions of phenomena. But the most important development given to the doctrine of Evolution in this volume was its affiliation upon the ultimate principle underlying all science—the persistence of force. It was shown that from this ultimate law there result certain universal derivative laws, which are dealt with in chapters on "The Correlation and Equivalence of Forces," "The Direction of Motion," and "The Rhythm of Motion," and it was demonstrated that these derivative laws hold throughout all changes from the astronomical to the psychical and social. It is then shown that "the Instability of the Homogeneous," "The Multiplication of Effects," "Segregation" and "Equilibration," are also deducible from this ultimate principle of the persistence of force. So that Evolution, having been first established inductively as universal, is further shown to be universal by establishing it deductively as a result of the deepest of all knowable truths.

The first edition of "First Principles" was published, but another important step in elucidating the philosophy of Evolution required to be taken. In dealing with the classification of the sciences, from the point of view to which his philosophy has brought him, Mr. Spencer had occasion to seek for that aspect of all physical phenomena which forms the most general division of physical science. He found that what he sought must be some general fact respecting the redistribution of matter and motion. The law was soon arrived at that integration of matter results from decrease of the contained motion, while disintegration of matter results from increase of the contained motion. It is at once manifest that the law thus reached was deeper than the principle of Evolution, for it is conformed to by mineral bodies which do not exhibit the phenomena of Evolution as Mr. Spencer had interpreted them. In short, it became clear that a law had been reached holding of all material things whatever, whether they are those which do, or those which do not, increase in heterogeneity. It was now first possible to judge of the relative value and importance of the several factors of the evolutionary process. In Von Baer's conception of organic development, it is made to consist essentially and solely in the change of increasing heterogeneity in the evolving body. But Mr. Spencer had shown that Evolution is a double process—a tendency to unity as well as to diversity, an integration as well as a differentiation. It was now found that the process of *integration*, as it applies to all things, whether evolving or not, is a deeper principle, and is, in fact, the *primary process* in Evolution, while the increase of heterogeneity is the *secondary process.* At the same time, this new view of the matter made it obvious that Dissolution is everywhere the correlative of Evolution, and that, before the generalization is complete, Dissolution must be recognized as universally tending to undo what Evolution does.

In a new edition of "First Principles," this idea was embodied, and the work recast in conformity with it. The doctrine of Evolution thus attained a higher development. The fundamental antagonism between Evolution and Dissolution comes into the foreground as the cardinal conception. It is shown that every aggregate, simple or compound, is, from the beginning to the end of its existence, subject to these opposing processes of change; that, according as its quantity of contained motion is becoming greater or less, it is tending to integrate or disintegrate—evolve or dissolve; that from moment to moment throughout its whole existence it is simultaneously exposed to both these processes, and that the average transformation it is undergoing expresses the predominance of the one process over the other. This being the universal law to which all material things at all times are subject, there come to be recognized certain derivative laws that are not universal, although highly general. Evolution is distinguished into simple and compound: simple Evolution being that in which the character of the matter and the rate of its integration are such that this primary process of change from a diffused state to a concentrated state is uncomplicated by secondary changes—compound Evolution being that in which, along with the general integrations, there go on more or less marked differentiations and local integrations. Thus the changes which were originally conceived to constitute Evolution itself came to be recognized as in order of time and importance subordinate; integration may go on without differentiation, as in crystals; but differentiation is made possible only by antecedent integration.

The doctrine of Evolution as a theory of the genesis and dissolution of things in the onward course of Nature was elaborately presented in "First Principles," and might have been there left to take its place and its chance among philosophical theories. But it had not been exploited by Mr. Spencer in the way of mental gymnastics, as a piece of novel and ingenious speculation. He believed it to embody a living and applicable principle of the greatest moment. If the law of Evolution be true, it is a truth of transcendent import, no less in the sphere of practical life than in the world of thought, and it was important that it should be carried out in the various fields of its application. Moreover, Mr. Spencer had been drawn to the investigation by his interest in the study of human affairs, and his task was but fairly begun with the establishment of the principle by which they are to be interpreted. In the strict logical order the next step would have been to trace the operation of the law in the inorganic or preorganic world, but the vastness of the subject forbade this, and Mr. Spencer found it necessary to enter at once upon the organic division of his scheme. In the "Principles of Biology" the subject of life was accordingly comprehensively dealt with from the Evolution point of view. He then passed to the phenomena of mind, and recast and amplified the "Principles of Psychology" in accordance with his more matured opinions, placing it upon the ampler basis afforded by "First Principles" and the "Principles of Biology." These three works, forming five volumes of the System of Philosophy, are now published, and they carry him half through the undertaking—the "Principles of Sociology," in three volumes, and the "Principles of Morality," in two volumes, remaining yet to be written. Mr. Spencer allowed twenty years for the whole enterprise; ill health and unforeseen interruptions have occasioned considerable delay, and it was half accomplished in twelve years.

A further illustration of the comprehensive and thoroughly systematic character of Mr. Spencer's work is afforded by his preparation for the treatment of the subject of Sociology. In dealing with Biology and Psychology, the data for reasoning were readily accessible, but in entering upon the scientific study of so vast and varied a subject as human society a most formidable difficulty appeared at the threshold of the inquiry, in the absence of facts to form the basis of sociological reasoning. So deficient and scattered and contradictory were such data that the possibility of any valid social science has been generally regarded with distrust, or unhesitatingly denied. But the phenomena of society are not chaotic; they coexist and succeed each other in an orderly way. The natural laws of the social state are undoubtedly determinable, but such determination is primarily a question of the collection of materials suitable for broad and safe inductions. Mr. Spencer foresaw this several years ago, and began the collection and methodical arrangement of all those numerous classes of facts pertaining to the various forms and states of society which are needed to work out the "Principles of Sociology." This alone was an immense undertaking. The races of mankind were divided into three groups, illustrating existing civilizations, extinct or decayed civilizations, and the savage state. Three corresponding series of works were projected, a tabular method for the classification and arrangement of facts was devised, and three gentlemen were employed to carry out the work of collection and digestion of materials under Mr. Spencer's supervision. The first installments of each of these divisions are now completed, and published. This important work, which is subsidiary to his main enterprise, is the first of the kind ever attempted, and when finished and issued will form a complete Cyclopædia of the multifarious data necessary for the scientific investigation of social questions. Its continued publication will depend upon public support; but the collection has been made by Mr. Spencer for his own use, and it will form the groundwork of the "Principles of Sociology" upon which he has now entered, and the first part of which is issued.

Let us now recapitulate his labors in the order of their accomplishment, so as to bring them into one view:

Letters on the Proper Sphere of Government,	1842
(Occupied several years as a Railroad Engineer.)	
Planned Social Statics,	1846
Social Statics published,	1850
Theory of Population, The Development Hypothesis, Philosophy of Style,	1852
Over-Legislation, The Universal Postulate,	1853
Manners and Fashion, The Genesis of Science, The Art of Education, *Evolution first conceived as Universal,*	1854
Principles of Psychology,	1855
(Breakdown of eighteen months.)	
Progress, its Law and Cause, Origin and Function of Music, Transcendental Physiology, Representative Government,	1857
State Tamperings with Money and Banks, Moral Education, The Nebular Hypothesis, Archetype and Homologies of the Vertebrate Skeleton, *Evolution first conceived as the Basis of a System of Philosophy,*	1858
The Laws of Organic Form, Physical Education, What Knowledge is of most Worth, Illogical Geology, *Prospectus of the System of Philosophy drawn up,*	1859
The Emotions and the Will, The Social Organism, The Physiology of Laughter, Parliamentary Reforms, Prison Ethics, *Prospectus of the Philosophical System published,*	1860
First Principles,	1862
Classification of the Sciences,	1864
Principles of Biology,	1867
Principles of Psychology,	1872
The Study of Sociology, Descriptive Sociology,	1873
Principles of Sociology, Part I.,	1874

The facts now presented, I submit, entirely sustain the view with which we set out, in regard to the character of Mr. Spencer's work, and his position in the world of thought. It has been shown that he took up the idea of Progress while it was only a vague speculation, and had not yet become a subject of serious scientific study. We have seen that he verified its reality by gradually tracing its operation step by step, in widely different fields of phenomena; that he analyzed its conditions and causes, and at length formulated it as a universal principle, to which the course of all things conforms. That view of the universe which the science of the world now accepts, it has been shown that Mr. Spencer adopted a generation ago, and entered upon its elucidation as a systematic life-work. We have traced the course of its unfolding, and I appeal to the record of labors here delineated as furnishing an example of original, continuous, and concentrated thinking, which it will be difficult to parallel in the history of intellectual achievement. In newness of conception, unity of purpose, subtlety of analyses, comprehensive grasp, thoroughness of method, and sustained force of execution, this series of labors, I believe, may challenge comparison with the highest mental work of any age.

As to the character of the system of thought which Mr. Spencer has elaborated, we have shown that it is such as to form an important epoch in the advance of knowledge. He took up an idea not yet investigated nor entertained by his predecessors or contemporaries, and has made it the corner-stone of a philosophy. If, by philosophy, we understand the deepest explanation of things that is possible to the human mind, the principle of genesis or Evolution certainly answers preëminently to this character; for what explanation can go deeper than that which accounts for the origin, continuance, and disappearance of the changing objects around us? It is the newest solution of the oldest problem; a solution based alike upon the most extended knowledge, and upon a reverent recognition that all human investigation, however extensive, must have its inexorable bounds. The philosophy of Evolution is truly a philosophy of creation, carried as far as the human mind can penetrate. If man is finite, the infinite is beyond him; if finite, he is limited, and his knowledge, and all the philosophy that rests upon knowledge, must be also limited. Philosophy is a system of truth pertaining to the order of Nature, and coextensive with it; and, as the various sciences are but the knowledge of the different parts of Nature, Mr. Spencer bases philosophy upon science, and makes it what may be called a science of the sciences. Resting, moreover, upon a universal law, which governs the course and changes of all phenomena, this philosophy becomes powerful to unify and harmonize the hitherto separate and fragmentary systems of truth; and, as this is the predominant trait of Mr. Spencer's system of thought, he very properly denominates it the *Synthetic Philosophy*.

In estimating the character of Mr. Spencer's Philosophical System, it is needful to remember that it differs in various fundamental respects from any that has before been offered to the world. It is more logically complete than any other system, because its truths are first derived from facts and phenomena by the method of induction, and then systematically verified by deduction from principles already established. It is more practical than any other, because it bears immediately upon common experience, takes hold of the living questions of the time, throws light upon the course of human affairs, and gives knowledge that may serve both for public and individual guidance. Viewed as an intellectual achievement, his undertaking is neither to be measured by the time consumed in its execution nor by the amount of labor involved, but by the nature and quality of the work itself. It was original throughout, was based upon the most comprehensive results of modern science, and was elaborated under the inexorable conditions of logical method. The development of a system of philosophy now is a very different thing from what it was in earlier times. Plato spun a system of thought before speculation was yet curbed by the knowledge of Nature; Spencer has constructed a philosophy out of the inflexible materials furnished in all the fields of modern investigation. His system is not a digest, but an organon; not merely an analytic dissection, but a grand synthetic construction; not a science, but a coördination of the sciences; not a metaphysical elaboration, but a positive body of doctrine conforming to verifiable facts, and based upon the most comprehensive principle of Nature yet arrived at by the human mind.

But no recognition of the greatness of Mr. Spencer's intellectual work will do him justice. There is a moral sublimity in his self-sacrificing career which is not to be neglected in making up the estimate of his character. As remarked by M. Laugel: "If Mr. Spencer, with his talents, his fertility of genius, and the almost encyclopedic variety of knowledge, of which his writings furnish the proof, had chosen to follow the beaten path, nothing would have been more easy than for him to secure all those honors of which English Society is so prodigal to those who serve her as she wishes to be served. He preferred, however, with a noble and touching self-denial, to put up with poverty, and, what is still more difficult, with obscurity." In advance of his generation and working against the powerful current of its prejudices, with broken health, without pecuniary resources, and depending upon promises of support that were but very partially redeemed, with an intrepidity that was not wanting in heroism, he entered upon the most formidable intellectual project that was ever undertaken by any single mind. One would think that it should have commanded the sympathy of the generous, and the cordial approval if not the kindly coöperation of all who appreciate courageous and noble endeavor; but, unhappily, a discriminating appreciation of genuine work is not over-abundant in these times, and, in the accomplishment of a task which I believe future generations will regard as the most memorable achievement of this fruitful age, Mr. Spencer has had but stinted encouragement and a very shabby support. In answer to the question, why his contemporaries have been so unappreciative, much might be said, but I will here confine myself to one or two suggestions.

In the first place, Mr. Spencer's work has been done under circumstances peculiarly unfavorable to the recognition of his rights as an original and independent thinker. Of the twenty-five articles prepared in the most active period of his life, and published between 1852 and 1860, which, as I have shown, are important contributions toward the development of the doctrine of Evolution in its various phases, most, if not all, appeared anonymously. They were printed in the different leading reviews, and many of them attracted marked attention at the time; but their author was unknown, and, of course, lost the advantage of having his ideas accredited to him. Up to the time when he had matured his system of thought, and was ready to enter upon its formal publication, he had been giving it out in fragments, as its several aspects had taken shape in his own mind. His articles, many of which were republished in this country, thus went far toward familiarizing the public mind with the general conception of Evolution, so that he was actually preparing his readers to discredit his subsequent claims to his own views, which, being reproduced and further diffused by others, were regarded as belonging to the common stock of current ideas. So far did this go, that he was ultimately exposed to the imputation of plagiarism for the restatement of opinions that he had first put forth, but which other men had appropriated and sent out as their own. Nor was the case much helped when he began to publish his System of Philosophy to subscribers, for so limited was its distribution that it might almost have been said that it was "printed for private circulation." Moreover, being the owner of his own works, the interests of publishers were not enlisted in their diffusion; while the assaults of the press were so malignant, and their representations so false, that for years he was constrained to withhold his series from the periodicals. All this was favorable to misconception, and left Mr. Spencer much at the mercy of dishonest authorship and unscrupulous criticism.

Again, it must be recognized that there were difficulties in appreciating his work which arose from its nature and extent. While a scientific discovery, or a single definite doctrine, is readily apprehended because the impression it makes is narrow and sharp, an extensive system of principles, which it requires power to grasp and time to master, can only be imperfectly received by the general mind. The very greatness of Mr. Spencer's work was thus an impediment to its recognition; and this, too, it must be acknowledged, on the part even of men of science. In the scientific world, the accumulation of facts has outstripped the work of valid generalization. For, while men of moderate ability can observe, experiment, and multiply details in special departments, it requires men of breadth to arrange them into groups, to educe principles and arrive at comprehensive laws. The great mass of scientific specialists, confined to their departments, and little trained to the work of generalization, are apt to regard lightly the logical processes of science, and to decry mere theorizing and speculation. They forget that facts of themselves are not science, and only become so by being placed in true relations, and that the function of the thinker is therefore supreme; while the work of organizing facts and establishing general truths is, after all, just as much a specialty as that of observation or experiment in any branches of inquiry. The prevalence of these narrow views has been unfavorable to the recognition of Mr. Spencer's work by a large class of the cultivators of science; and the more so, as he has been mainly occupied in the highest spheres of generalization. For this reason it is only by the comparatively small number of scientific men, who possess marked philosophic power, that his labors have been justly appreciated.

But, while considerations of this kind are not to be overlooked in assigning the responsibilities of criticism, neither are they to be construed into excuses for prejudiced opinions, or crude and hasty judgments. It is the business of critics to inform themselves on important matters of which they speak, or to hold their peace. And, where there is peculiar difficulty or liability to error, they are all the more bound to caution, and to refrain from injurious interpretations. Reverting, now, to the criticisms cited at the outset of this discussion as typical of a class, we are prepared to rate them at what they are worth.

From what has been stated, I think it will be sufficiently evident that Mr. Spencer is no follower of Comte, Darwin, or any other man, and that he has pursued his own independent course in his own way. As to M. Taine's statement that "Mr. Spencer has the merit of extending to the phenomena of Nature and of mind" Mr. Darwin's principle of Natural Selection, the facts given show how mistaken was his view of the case. Strange to say, M. Taine, who claims to be a psychologist, puts forth this idea in a review of Mr. Spencer's "Principles of Psychology," a work which treated the subject of mind throughout, and for the first time from the point of view of Evolution, and this years before Mr. Darwin had published a word upon the subject.

As this error of M. Taine is frequently repeated,[1] and indicates a gross misapprehension of the subject, it is desirable to add a word or two regarding Mr. Darwin's relation to the question. While he has contributed immensely toward the extension and establishment of a theory of organic development, he has never made even an attempt to elucidate the law of Evolution as a general principle of Nature. His works do not treat of this problem at all, and nothing has tended

[1] Another example of it has just been furnished by the *Saturday Review*, which, in commenting upon Prof. Tyndall's late address, remarks: "What Darwin has done for physiology, Spencer would do for psychology by applying to the nervous system particularly the principles which his teacher (!) has already enunciated for the physical system generally."

more to the popular confusion of the subject than the notion that "Darwinism" and Evolution are the same thing. Mr. Darwin's fame rests chiefly upon the skill and perseverance with which he has worked out a single principle in its bearing upon the progressive diversity of organic life. The competitions of Nature leading to a struggle for existence, and that consequent winnowing which Mr. Darwin calls "Natural Selection," and Mr. Spencer calls "Survival of the Fittest," were recognized before Mr. Darwin's time: what he did, as I have before explained, was to show how this principle may aid in giving rise to new species from preëxisting species. But this principle is secondary and derivative, and its operation may be traced, as Mr. Darwin has traced it, without going back to those primary forces, the resolution of which constitutes the radical problem of Evolution.

The principle which Mr. Darwin promulgated is a part of the great theory, and it has a philosophic importance, exactly in proportion to the validity of that larger system of doctrine to which it is tributary as an element. Not only has Mr. Darwin never taken up the question of Evolution from a scientific point of view, but it was not his aim to explain even the evolution of species in terms of ultimate principles, as a part of the universal transformation—that is, in terms of the redistribution of matter and motion; for it is in this way that all proximate principles, including Natural Selection, have to be expressed before the final interpretation is reached. This mode of dealing with the subject, the only thoroughly scientific method of its treatment, belongs to Mr. Spencer alone. As to his following Mr. Darwin, we have already seen that, two years before the "Origin of Species" was published, Mr. Spencer had reached the proof of Evolution as a universal law; had traced its dependence upon the principle of the Conservation of Force; had resolved it into its ultimate dynamical factors; had worked out many of its important features; had made it the basis of a system of Philosophy; and had shown that it furnishes a new starting-point for the scientific interpretation of human affairs.

Colonel Higginson imputes to Mr. Spencer, as a weakness, the propensity to write on a great number of subjects; I have shown, on the contrary, that he has been compelled to write upon many subjects from logical necessity, and has done so in unswerving devotion to the development of one class of ideas. It will be seen that he is now upon the same identical track of thought which he opened in his youth, to which he has consecrated his life, and which he has made his own. Thirty-two years ago he began to study the social condition and relations of men from the scientific point of view, and to treat of human society as a sphere of natural law. After eight years he published a treatise upon the question, which, although in advance of the times, only served to convince its author that the investigation was barely begun, and that, before any adequate social science was possible, the whole subject required to be more deeply grounded in the knowledge of Nature. Upon that deeper study of Nature he then entered, and, after twenty-four years of steady and systematic preparation, the problems of Social Statics are resumed in the "Principles of Sociology." If so prolonged and inflexible a course of original inquiry, yielding results which are felt in the highest spheres of thought, are suggestive of "a weakness," we should be glad to be furnished with the examples which embody Colonel Higginson's conception of strength in mental character. As to the declaration that it seems absurd to attribute to Mr. Spencer any vast enlargement or further generalization of the modern doctrine of Evolution, we leave its author to reconcile his opinion with the fact that the System of Psychology, which first extended the principle of Evolution to the sphere of mind, had been nine years before the world—the conception of universal Evolution had been formulated and promulgated four years, and "First Principles" had been for some time published, when this statement was made.

Mr. Emerson's criticism of Spencer is summary and decisive, as becomes a man who has gone to the bottom of a subject. Reticent and mystical no longer, he plumps out his opinion, when interviewed, with all the confidence of one who knows what he is talking about. Into the pantheon of immortals, arranged for the reporter of Frank Leslie's newspaper, none may enter but star-writers, and Mr. Spencer is only a "stock-writer." We may, however, presume that Mr. Emerson has here followed his transcendental lights, as there are many who will insist that he is not for a moment to be suspected of having ever read Mr. Spencer's books; though it will still remain a mystery how he has so skillfully contrived to make his statement as exactly wrong as it could be made. It will, probably, matter little to Mr. Spencer what Mr. Emerson thinks of his position, as it can matter nothing to Mr. Emerson what we think of his judgment; but it should matter a good deal to him that he do not lend the influence of his eminent name to the perpetration of injustice. Speaking in the light of the facts here sketched, we say that Mr. Emerson will search the annals of authorship in vain to find an instance in which his epithet would be more grossly misapplied. And we will do him the justice to say that in other days he has taught us a more generous lesson in regard to what is due from the manly and liberal-minded to the heroic endeavors of noble and unrecognized men. Many of his admirers will recall with pleasure the following admirable passage: "What is the scholar, what is the man *for*, but for hospitality to every new thought of his time? Have you leisure, power, property, friends? you shall be the asylum of every new thought, every unproved opinion, every untried project, which proceeds out of good-will and honest seeking. All the newspapers, all the tongues of to-day, will, of course, at first defame what is noble; but you, who hold not of to-day, not of the times, but of the everlasting, are to stand for it; and the highest compliment man ever receives from Heaven is the sending to him its disguised and discredited angels." This is a grand exhortation, and has, no doubt, thrilled many a reader with enthusiasm for the rising thoughts of his time. But the difficulty still remains, how to identify the celestial messengers! Such are the eccentricities of human judgment, that the sympathy which Mr. Emerson invokes is as likely to be given to the worthless as to the worthy. And what shall we say about the duty of common mortals respecting the "disguised and discredited angels," when the Seer himself snubs the author of "First Principles" as a "stock-writer," and says to the author of that unclean imposture—"Leaves of Grass"—"I greet you at the beginning of a great career?"

HUMAN LOCOMOTION.

THE movements executed by animals in transporting themselves from place to place have long engaged the attention of observers; and, as animals which travel on the land are more easily got at than those which frequent the sea and the air, it is the motions of such that we know most about. Yet much remains to be learned of the modes of progression of even the most familiar of these; and not a little probably will have to be unlearned that recent investigations have shown to be erroneous.

At first sight, the operations of walking and running, as displayed by both two-legged and four-legged creatures, may appear simple enough, but all attempts to analyze and explain them have shown that in reality they are very complex, so that there has arisen a wide diversity of opinion concerning their real nature. These disagreements among the investigators of the subject can only be accounted for on the principle of the insufficiency of the means at their command for complete investigation; and the confusion has been further increased by the difficulty of expressing in words the rhythm, duration, and phases of the rapid and complex movements involved.

Prof. E. J. Marey, of the College of France, a skillful physiologist, and the inventor of the various delicate mechanical appliances for tracing and registering obscure animal motions, has contributed to the "International Scientific Series" a work entitled "Animal Mechanism," in which the subject of terrestrial locomotion, as typified in man and in the horse, is fully treated. Prof. Marey has devised an apparatus which, applied to the extremities of a moving animal, enables each limb to write out a description, or make a picture of its own actions, so that the duration and phases of its movements, its periods of rest, and the relations of these to the corresponding features in the motions of the other limbs, may be seen at a glance. A description of this apparatus, and its mode of operation, with the results that it gives when applied to man, will first engage our attention.

For the sake of clearness, the machine may be described as con-

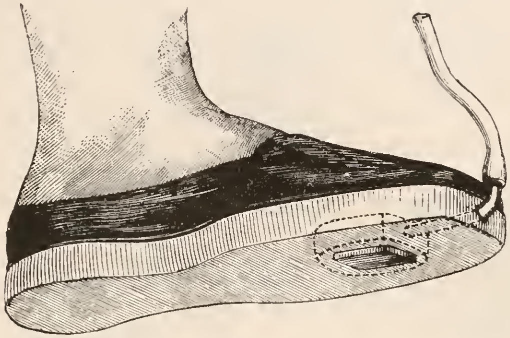

FIG. 1.—EXPERIMENTAL SHOE, INTENDED TO SHOW THE PRESSURE OF THE FOOT ON THE GROUND, WITH ITS DURATION AND ITS PHASES.

sisting of two parts, one of which is applied to the limb, and is called the *experimental shoe*, while the other is carried in the hand of the operator, and is simply a registering instrument, connected with the shoe by an India-rubber tube. The experimental shoe is made by

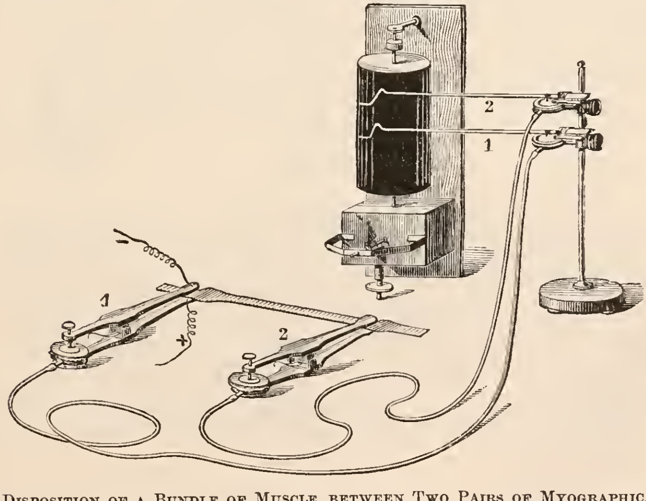

FIG. 2.—DISPOSITION OF A BUNDLE OF MUSCLE BETWEEN TWO PAIRS OF MYOGRAPHICAL CLIPS Clip No. 1 holds the electric excitators of the muscle. A wave is represented at the moment when it has just crossed each of the clips.

fixing under the sole of an ordinary shoe, with heated gutta-percha, a strong sole of India-rubber about five-eighths of an inch thick. Within this sole there is an air-chamber, which, in Fig. 1, is represented by dotted lines.

This chamber, having upon it a small piece of projecting wood, is compressed at the moment the foot exerts its pressure on the ground. The air expelled from this cavity escapes by the tube, actuating the recording instrument in the hand of the experimenter, causing it to register the duration and phases of the pressure of the foot.

Fig. 3.—Runner provided with the Apparatus intended to register his Different Paces.

The registering instrument consists of a little drum, with its upper side formed of some elastic membrane. On this membrane rests a lever having the point of its long arm in contact with the surface of a revolving cylinder, which may be made to move at any required rate, and which carries a slip of paper prepared to receive the tracings. Fig. 2 is a representation of this instrument as employed in registering the transverse dilatation of muscular fibre in the process of contraction. If we substitute in this figure an experimental shoe for each of the myographical clips, 1 and 2, we shall have the arrangement of the apparatus necessary for the study of *footsteps* or *impacts* of the foot on the ground.

The entire apparatus, as adjusted to the person of the operator, is seen in Fig. 3. The piece of machinery on the head will be described when we come to speak of the movements communicated to the trunk by the actions of the legs.

To understand the indications which the working of the apparatus gives, the reader is referred to Fig. 4, which has been furnished by an experiment in walking. Two tracings are given by the intermittent pressure of the feet on the ground. The full line *D* corresponds with the right foot; the dotted line *G* with the left. The lines are read from left to right.

Knowing the arrangement of the apparatus, we can understand that each impact of the foot on the ground will be represented by the elevated part of the corresponding curve. The pressure of the foot on the ground compresses the India-rubber sole and diminishes the capacity of the included air-chamber; a part of the contained air escapes by the connecting tube, and passes into the registering drum. The elastic side of the latter is thus elevated, carrying up the point of the lever, which in turn leaves the mark of its movement on the paper carried by the revolving cylinder. Were the lever to remain undisturbed, it would simply make an horizontal line running round the cylinder; but, with the apparatus in use, each impact of the foot lifts the pen-point of the lever, thus giving the curves traced in the figure. It will be seen that the pressure of the right foot commences at the moment when that of the left begins to decrease; and that in all the

Fig. 4.—Tracings of the Impact and the Rise of the Two Feet in our Ordinary Walk.

tracings there is an alternation between the impacts of the two feet. The period of *support* of each foot is shown by an horizontal line which joins the minima of two successive curves. The impacts of the right and left feet are seen to have the same duration, showing that the weight of the body passes alternately from one foot to the other. It would not be the same in respect to a lame person; lameness corresponds essentially with the inequality of the impacts of the two feet.

The curves traced by walking may also furnish the measure of the effort exerted by the foot upon the ground. The experimental shoes constitute a sort of dynameter of pressure; they compress the drum less or more according to the effort they exert, and consequently transmit to the registering lever more or less extensive movements. In order to estimate, according to the elevation of the curve, the pressure exerted by the foot, we must substitute for the weight of the body a certain number of pounds. We see thus that, if the weight of the body (150 pounds for example) is sufficient to raise the lever to the height it attains at the commencement of each curve, an additional weight will be required to raise it to the maximum elevation which it attains toward the end of its period of pressure. This proves that, in walking, the pressure of the foot on the ground is not only equal to the weight of the body which the foot sustains, but that a greater effort is produced at a given moment in order to elevate and move the body forward. This additional effort, in a man of average weight, is estimated at about forty pounds, and it is much greater in running and leaping.

There are certain oscillations of the body, both vertical and horizontal, produced by the actions of the legs, which M. Marey has carefully traced, but which, owing to their extreme complexity, are difficult to explain. We shall therefore pass them with only a glance, referring the reader to the work itself for details. With each step there is an up-and-down movement of the body, which varies with the length of the step and the rapidity of the pace. In ordinary walking it has an amplitude of from half to three-quarters of an inch. The maximum of these vertical oscillations is constant, and occurs during the pressure of the foot upon the ground, at the moment when the leg is brought into a straight position. The minima, and consequently the extent of the oscillations, will be determined by the length of the step; the longer the step the greater the obliquity of the legs, and, of

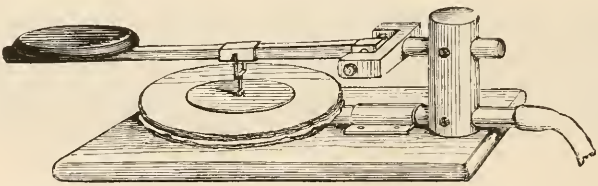

Fig. 5.—Instrument to register the Vertical Reactions during the Various Paces.

course, the greater the lowering of the trunk. Put in another form, it amounts to this: in ordinary walking, the body does not rise above the line of its greatest height when standing still, and the distance which it sinks below this line will increase as the length of the step increases.

The instrument by which M. Marey obtains the tracings of these vertical reactions is represented in Fig. 5.

It is an experimental lever-drum, fixed on a piece of wood, which is fastened with moulding-wax on the head of the experimenter, as seen in Fig. 3. The drum is provided with a piece of lead placed at the extremity of its lever; this mass acts by its *inertia.* While the body oscillates vertically, the mass of lead resists these movements, and causes the membrane of the drum to sink when the body rises, and to rise when the body descends. From these alternate actions a current of air results, which, transmitted by a tube to a registering lever, shows by a curve the oscillatory movements of the body.

A complete horizontal oscillation occupies the time of two steps, and, consequently, of two vertical oscillations. The body is carried toward the right side, at the moment of the maximum of elevation, which corresponds with the middle of the pressure on the right foot, and toward the left at the middle of the pressure on the left foot. This lateral swaying of the trunk is the consequence of the alternate passage of the body into a position sensibly vertical over each foot.

The body is advancing at every moment during the step, but at some parts of it more rapidly than at others. The greatest rapidity of advance is at the end of the pressure of the foot.

With this brief sketch of the movements of the limbs and body in walking, and of the apparatus employed by M. Marey for studying these movements, we are prepared to consider the different paces common to man.

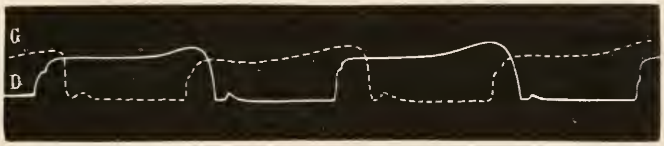

Fig. 6.—Tracing produced by Walking Up-stairs.—*D*, tracing of the pressure and rise of the right foot (full line); *G*, tracing of the left foot (dotted line).

In walking, the body does not leave the ground, the footsteps follow each other without any interval, and the weight of the body passes alternately from one foot to the other. The tracings in Fig. 4, obtained by walking on a level surface, illustrate these points. There are exceptions, however, to this definition. For example, in mounting a staircase it will be observed that the step-curves encroach on each other (Fig. 6), showing that each foot is still pressing on its support when the other has already planted itself on the next step. Besides this, it is at the time of this double pressure that the lower foot exerts its maximum force; it is at this moment, in fact, that the work is produced which raises the body to the whole height of a step. Nothing like this is observed in the descent of a staircase; the step-curves cease to encroach on each other, following one another very much as in ordinary walking on level ground.

Running, though more rapid than walking, consists like it in alternate treads of the two feet, whose step-curves follow each other at equal intervals; but it presents this difference, that in running the body leaves the ground for an instant at each step. Fig. 7 shows the principal characters of this mode of progression. The pressures of the feet are more energetic than in walking; in fact, they not only sustain the weight of the body, but impel it with a certain speed both upward and forward. It is clear that, to give a mass a rising motion, a greater effort must be exerted than would be sufficient simply to sustain it. The duration of the pressures on the ground is less than in walking; this brevity is proportional to the energy with which the feet tread on the ground. These two elements—force and brevity of pressure—increase generally with the speed at which a person runs. The essen-

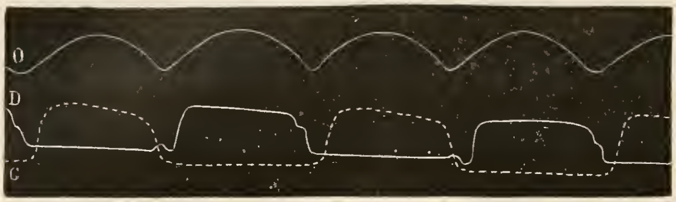

Fig. 7.—Tracing produced by Running (in Man).—*D* (curve formed by a full line), impact and rise of right foot; *G* (dotted line), action of the left foot; *O*, oscillations and vertical reactions of the body.

tial character of running is *the time of suspension*, during which the body remains in the air between two foot-falls. Fig. 7 clearly shows the suspension by the interval which separates the descent of the curves of the right foot from the ascent of the curves of the left foot, and *vice versa*. The duration of the time of suspension appears to vary but little in an absolute manner; but, if we compare it with the speed of the runner, we see that the relative time occupied by this suspension increases with the speed of the course, for the duration of each tread diminishes in proportion to this speed. How is this suspension of the body, at each impulse of the foot, produced? We might at first think that it is the effect of a kind of leap in which the body is projected upward in so violent a manner, by the impulse of the feet, that it would describe in the air a curve, in the midst of which it would attain its maximum elevation from the ground. We may convince ourselves that such is not the case by reference to Fig. 7. The upper line (*O*) is a tracing of the vertical oscillations in running. It shows that the body executes each of its vertical elevations during the *downward pressure* of the foot, so that it begins to rise the moment the foot touches the ground; it attains its maximum elevation at the middle of the pressure of this foot, and begins to descend again in order to reach its minimum at the moment when one foot has just risen, and before the other has reached the ground. This relation of the vertical oscillations to the pressure of the feet shows plainly *that the time of suspension* does not depend on the fact that the body projected into the air has left the ground, but that the *legs have withdrawn from the ground* by the effect of their flexion; and this takes place at the very moment when the body was at its greatest elevation.

Galloping, a gait that children in their amusements sometimes adopt, gives the tracings shown in Fig. 8. The tracings produced by leaping are shown in Fig. 9.

FIG. 8.—MAN GALLOPING WITH THE RIGHT FOOT FIRST.—Step-curves and reactions. There is an encroachment of one curve over the other, and then a suspension of the body. The curve *O*, which corresponds with the reactions, shows the effect of the two successive impulses exerted on the body by the feet.

Among the characters belonging to the various modes of progression, the rhythm of the impact of the feet is one of the most striking. The strokes of the feet upon the ground give rise to sounds the order of whose succession is sufficient for a person, with an ear accustomed to them, to recognize the kind of pace which produces them. In order to give the figure of each of these rhythms, Prof. Marey employs the musical notation, modified so as to furnish at the same time the notion of the duration of each pressure, that of the foot to which this pressure

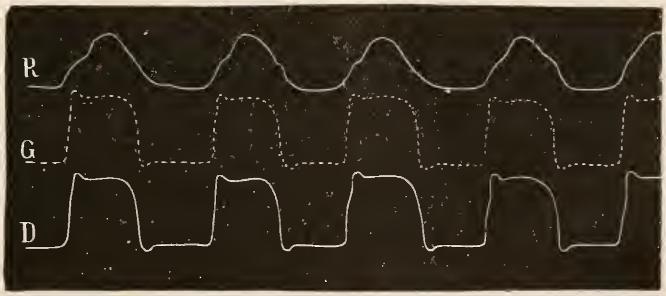

FIG. 9.—LEAP ON TWO FEET AT ONCE (*D* AND *G*).—The line *R*, the curve of reactions, shows that the maximum of elevations corresponds with the middle of the pressure of the feet.

belongs, and also the length of time during which the body is suspended. This notation of rhythms is constructed in a very simple manner from the tracings furnished by the apparatus. Fig. 10 represents the curve which corresponds with the act of running in man. Below this figure let us draw two horizontal lines, 1 and 2; these will form the *staff* on which will be written this simple music, consisting only of two notes, which M. Marey calls *right-foot* and *left-foot*. From the commencement of the ascending part of one step-curve belonging to the right foot we will let fall upon the staff a perpendicular (*a*); this line will determine the commencement of the pressure of the right foot. A perpendicular (*b*) let fall from the end of the curve will determine where the pressure of this foot ends. Between these two points let us trace a broad white line; it will express, by its length, the duration of the pressure of the right foot. A similar construction

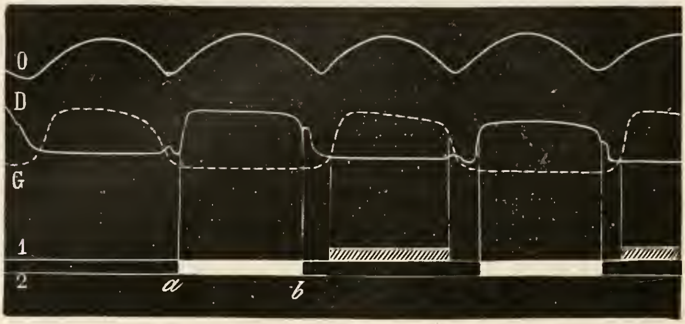

FIG. 10.

made on line 1, from the succeeding step-curve, will give the notation of the pressure of the left foot. The notations of the left foot have been shaded with oblique lines, to avoid confusion.

Between the pressure of the two feet there is found to be silence in the rhythm; that is to say, the expression of that instant of the course when the body is suspended above the ground.

If we note in this manner the rhythms of all the paces used by man, we shall obtain a synoptical table which will much facilitate the comparison of these varied rhythms. Fig. 11 represents the synop-

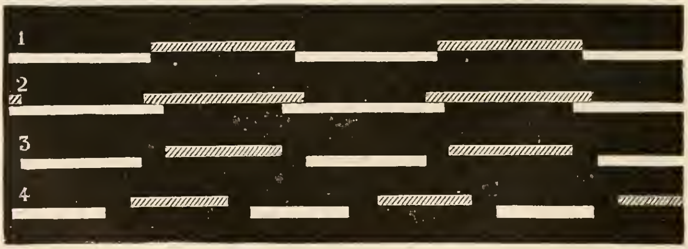

FIG. 11.—SYNOPTICAL NOTATION OF THE FOUR KINDS OF PROGRESSION USED BY MAN.

tical, of the four kinds of progression, or paces, which are regularly rhythmical, and in which the two feet act alternately. Line 1 represents the notation of the rhythm of the walking-pace. The pressure of the right foot upon the ground is represented by a thick white stroke, a sort of rectangle, the length of which corresponds with the duration of the pressure. For the left foot there is a grayish rectangle shaded with oblique lines. These alternations of gray and white express by their succession that in walking the pressure of one foot succeeds the other, without allowing any interval between the two.

Line 2 is the notation which corresponds with the ascent of a staircase. It is seen that the strokes lap, or encroach on each other, and that, consequently, the body during an instant rests on both feet at once.

Line 3 corresponds with the rhythm of running. After a shorter pressure of the right foot than in the walking-pace, an interval is seen which corresponds with the suspension of the body; then a short pressure of the left foot followed by a fresh suspension, and so on continually.

Line 4 answers to a more rapid rate of running. It shows a shorter duration of the pressures, a longer time of the suspension of the body, and a more rapid succession of the various movements.

This method of representing the different modes of progression by the notation of their rhythms, though hardly necessary to make clear the simple paces of man, will greatly aid us in understanding the more complicated paces of the horse, which will be the subject of another article.

EDUCATED TO DEATH.[1]

A MOTHER'S STORY.

AT the age of fifteen Mary was a remarkably fine and healthy girl: she seemed to be safely over the critical period, and, till after that time, had never suffered as many girls do at the commencement of their womanhood. Her thinking powers were quick and vigorous, and she was the pride of her teachers and joy of her parents. Unlimited mental progress was laid out for her, and it seemed that there were to be no bounds to her acquirements.

She had then finished a good common-school education, at the best high-school, and had entered an institute for young ladies (a boarding-school) of the highest character. The curriculum of study

[1] From "The Building of a Brain," by Edward H. Clarke, M. D. The appearance of this narrative in Dr. Clarke's volume is thus explained by him in the following prefatory remarks:

"Last February I received a letter from a gentleman, personally a stranger to me, but well known as an accomplished scholar and writer, to the effect that the case of his daughter, who died less than a year previous, aged eighteen, would furnish an excellent illustration of the evil results of inappropriate methods of female education, and that he would be willing to have the history of her case published, if its publication would render any service to the cause of sound education. In reply to a request for the history which he had so kindly and unexpectedly offered to prepare, the following note was re-there was comprehensive, and it required the closest application of an ambitious scholar to succeed.

One hour was allowed for walking and recreation during the day; and half of that hour could be spent, if the pupil desired to do so, in the music-room. As the months went on, I began to notice that her complexion, which had been pure rose-leaf, became almost transparent, and that the fresh blood left her cheeks: still she did not complain nor lose flesh, but said sometimes, if she could *sleep a week* she would enjoy it, and that it almost always happened, when she was unwell, she had the most to do, and the longest to stand. Her progress in her studies was wonderful; and it seems incredible to me now that we should have let her devote herself so entirely to them. Her musical talents were great, and they were under cultivation also: when she was seventeen she was the first soprano singer in the choir of the church to which she belonged.

At last I began to be alarmed at the remarkable flow whenever she was unwell, and at the frequent recurrence of the periodical function. I felt as if something should be done, and consulted our family physician as to what could be given her, and how this increased action could be stopped or diminished.

He prescribed iron as a tonic, but said that we should do nothing more; for that "every woman was a law unto herself," and, as long as nothing more serious occurred, she was to be let alone. This from a man who had daughters himself, and eminent in the profession! Never a word about rest, never a caution that she could overwork herself, and thus bring misery for the remainder of her life. She left school, in June of that year, with noble honors and an aching frame, and, after two months' vacation and rest, which seemed to do her a world of good, began in September another year of unremitting hard study. Loving and gratified parents, proud and expectant teachers, looked upon her as capable of accomplishing all that had ever been done by faithful students, and of advancing far beyond all who were in the graduating class with her.

Her teachers were as kind as any could have been. I think the fault was in the system that requires so many hours of study, no matter what the condition of the pupil may be.

ceived, which forms an appropriate and sufficient preface to the sad account that follows it:

'*March* 30, 1874.

'Dear Sir: The inclosed statement is from the pen of my wife. If it can serve the right, you are at liberty to make use of it—in whole or in part, in the language in which it now stands, or in modified or entirely different language—as in your judgment may seem best. You, of course, will not give names, certainly not in full.

'Very truly, ——— ———.'

"It is proper to say that, except a few slight verbal alterations, which the writer herself would probably have made if she had corrected the proofs of her manuscript, no changes have been ventured upon in the language by which a mother presents the instructive lesson of her daughter's method of education, and its result."

As an instance, twenty-five questions were given her to be answered. She was seated at a table, without books, from 10 A. M. till 8 P. M., ceaselessly *thinking* and writing; and the twenty-five questions in classical literature were faultlessly answered, and that, too, at a time when, had I known what I know now, she should have been resting on her bed.

Her father, to whom the paper was shown for his approval, wrote on the margin: "It seems to me that the task imposed here was a *great one*, *indeed;* but it has been performed with good success." I do not for a moment mean to find fault with her teachers, for kinder, more interested ones no pupil ever had; and the delight that a teacher derives from a painstaking and appreciative pupil cannot be understood by those unused to teaching.

While the dear child was meeting our utmost requirements as a scholar, the foundations of her life were being sapped away.

In May, 1872, a little more than two weeks before the June commencement, she was taken with fearful sickness and severe chills, just after one of the hæmorrhages that came every three weeks regularly. Our doctor was called, and the first thing she said to him was: "Doctor, I must not be sick now. I cannot afford the time. I *must* be well for commencement." For four days she suffered very much, but quinine and all sorts of tonics brought her up; and the two weeks that should have been taken to get well in were spent in study, study, study. All the examinations were passed successfully, even brilliantly, and she was graduated with all the honors of the institution. Oh, how proud we were of her! and when she came home, frail and weak as a wilted flower, we said that she should have a long rest, and every comfort that we could give her.

All summer she remained in the Highlands of the Hudson; yet, when autumn came, she was not as well as we thought she ought to be, though very much improved with regard to the monthly turns, they recurring at right times now.

In September she commenced studying again; her French and music were continued, so that she might become still more accomplished in those branches, and lectures on rhetoric and moral philosophy were attended also.

The habit of studying was so strong upon her that she could not give it up. Now came swelling of the joints and fingers, and the old trouble, all of which she would have kept to herself if she could have done so; but I was so anxious about her that I ascertained her condition, went to the doctor again, and begged him to tell me what to do that would stop the weakening periodical disturbance, as I was persuaded that was the cause of her trouble. He said she had inflammatory rheumatism, and prescribed *soda*. But I was not to do any thing for the other matter, and, against my own convictions, I let things take their course. Oh, if he had said, "Take her home, and stop her studying!" Armed with such authority, I should have done it, and how do we know but she might have been with us now if I had done so?

But, she worked on till the 25th of December. Then she came home, and said decidedly she would study no more till she was *well.*

We were rejoiced at her decision; for, although we were anxious that her education should be completed and thorough, we had felt for a long time that her health was becoming impaired. Still we were sure she had a good constitution, and thought that would carry her through. She did not grow thin, but *stout* and *pale*, and such a transparent pallor, that, now I think of it, I wonder all who looked at her did not see that her blood was turning to water. Her sweet and lovely soul was so uncomplaining, and her smile always so bright, that we never for a moment thought *she could* fade and die.

She brightened up somewhat for the next month, but still did not "get well." About the last of January her limbs swelled so much that, in haste, I rushed to the doctor. Then he said her kidneys were congested, and that Bright's fatal disease was her malady. All that despairing love could do was done *now.* In five short weeks we laid her in Greenwood. Whatever was the form of the disease from which she suffered, I am convinced that what she did have was brought on by incessant study when she should have rested, and that it was fixed at the time that she got the severe chills—in May, 1871.

She was by no means a frail girl when she entered the institute. She was tall, finely formed, with a full, broad chest, and musical organs of great compass. Her bust was not flat, neither was it as full as it might have been. Her features were not too large. She had brown eyes, brown hair, a very sweet and pleasing face. With every indication at first of strength and a good constitution, she fell at last a victim to want of sense in parents and teachers, and—shall I say?—physician too.

THE RESPIRATION OF PLANTS.

By ÉMILE ALGLAVE.

TRANSLATED FROM THE REVUE SCIENTIFIQUE, BY J. FITZGERALD, A. M.

I.

THE functional contrast between the two organic worlds of plants and animals was, till lately, the groundwork of all scientific speculations. The labors of the most illustrious men of science had confirmed this theory; and then, too, it was in accord with all the known facts.

Plants, it was held, grow in order to supply animals with food, and to make life possible for them; the activities of vegetal life produced the immediate principles of food, and animal life destroyed them; the various excretions of animal life were the natural ferment of vegetal life, and the latter purified the air, contaminated by animal emanations; finally, that function of the organism which is most continuous, namely, respiration, consisted, in animals, in the absorption of oxygen, followed by exhalation of carbonic acid, while in plants it consisted in the absorption of carbonic acid, followed by exhalation of oxygen. In this way the respiration of plants would decompose the carbonic acid produced by the respiration of animals, thus preserving the normal constitution of the atmosphere.

The famous experiments of Claude Bernard on the glycogenic function of the liver, revealing, as they did, the formation in the liver of animals of one of the most important of these immediate principles, to wit, sugar, delivered on this apparently philosophic and well-established theory a severe blow, from which it could not recover. Soon, a very different theory, one no less philosophic in its general form, was proposed; and this theory was so bound up with the tendencies of modern science and philosophy, that its success was assured from the outset. In place of the harmonic contrast of the two kingdoms, we have now the functional unity of living Nature. Our readers have not forgotten the lectures delivered during several years by Claude Bernard, at the Paris Museum of Natural History, in which he has developed this grand conception. Instead of comparing together animals and plants, pointing out their differences, as the usual course has been, Bernard enumerates their resemblances; and this simple change in the point of view at once gives to the *ensemble* of the facts a very different meaning.

But, still there appear to remain some fundamental differences, chiefly with regard to respiration.

Since the date of the early researches, which made out the respiration of plants to be an exhalation of oxygen resulting from the decomposition of the carbonic acid of the atmosphere, sundry not very recent experiments have to a certain extent limited the bearings of the original conclusions. It was soon discovered that this mode of respiration is subordinated to the action of solar light, and that it occurs only in the leaves and in the green portions of the plant, the coloration being due to the presence of a special principle called chlorophyll; and thus the chlorophyll came to be regarded as the organ, the essential agent of plant-respiration. Next, the discovery was made that the flowers of a color different from green, and even the green portions themselves when placed in the dark, not only do not absorb carbonic acid out of the atmosphere, and then exhale the oxygen of that acid; they go further, and do the very opposite, absorbing oxygen and giving up carbonic acid, just as animals do.

Hence the assignment to plants of a second mode of respiration, known as *nocturnal*, as opposed to the other mode, called the *diurnal* respiration. But, notwithstanding the discovery of a number of facts which tended to enlarge the province of this so-called nocturnal respiration, it was far from attaining the importance of the diurnal, which all the botanists held to be the true respiration of plants, and which, as compared with the other mode, clearly deserved this distinction, owing to the number, the duration, and the extension of the phenomena which it represented.

One might wonder at this strange duality of respirations in a single being—respirations that were antagonistic in their very essence; especially might one ask how plants could be deprived, during one-half of their life, of that physiological function, the unceasing performance of which would seem to be the most indispensable of all, to wit, the respiratory function—for this was held to be identical with the diurnal respiration; it might even be observed that certain plants, grown in the dark, perform this function very seldom; but, for all that, the facts all seemed to require the acceptance of the current theory.

These preliminary remarks will enable the reader fully to see the importance of the researches recently explained to the Lille Society of Sciences, by M. Corenwinder, of whose paper we propose to give a summary. The author, who has for twenty years pursued in one direction his studies of vegetal physiology, has proved that the nocturnal respiration of plants, though supposed to be exceptional, is in fact perfectly continuous, and constitutes their only true respiration. What hitherto has been called diurnal respiration, viz., the absorption of carbonic acid, the seat of which is the chlorophyll, instead of being the true respiratory phenomenon, is a phenomenon of assimilation and digestion, as pointed out by Claude Bernard. Plants and animals respire both in the same way. This is the grand fact, the proofs of which are given by Corenwinder.

II.

Buds, young shoots, and nascent leaves, discharge a function hitherto insufficiently considered, but yet this function is of such a nature as to elucidate the most important laws of vegetal physiology. It may be readily shown by very simple experiments that, in this first period, and *for a certain length of time*, plants absorb oxygen *unmistakably and uninterruptedly*, exhaling carbonic acid. Nor is it only in the dark that they discharge this function; indeed, it is not very apparent during the night, when the weather is cold, as is often the case in spring. It is during the day, and when the sunlight is strongest, that this function becomes characteristic, and especially when the temperature is rising.

This is easily shown by placing delicate plants, gathered in the early stages of their growth, under a close bell-glass, connected with a receiver holding concentrated baryta-water, the receiver in turn being connected with an aspirator, which causes the air in contact with the plant to pass gently over the baryta solution. For instance, take a freshly-opened bud of the chestnut, and presently, or at least after a very little while, there is seen to form, in the daylight, a deposit of carbonate of baryta, and this increases very rapidly. Of course, care must be taken to deprive the air of its carbonic acid before it is admitted into the bell-glass.

A very simple experiment will make it plain that, in the course of this first period, the nascent leaves absorb to an appreciable extent the oxygen of the air both day and night. We have only to place the plant in a small bell-glass containing common air, the mouth of the vessel being stopped by means of a solution of caustic potash in a saucer. Soon we observe the solution rising in the bell-glass, and standing still at a certain point, which it never goes beyond. (Care must be taken not to allow the alkaline liquid to touch the petioles of the leaves.) If we now examine the elastic fluid which remains unabsorbed, we find that it contains nothing but nitrogen. In this operation the oxygen is inhaled by the leaves, which transform that gas into carbonic acid; this they expire in variable proportions according to their age, and it is absorbed by the caustic-potash solution.

But this power of absorbing oxygen and of exhaling carbonic acid in the daytime, while very evident at the instant of the opening out of the buds, becomes sensibly less pronounced, according as the leaves grow, and, as a general rule, this phenomenon ceases to be presented after these organs have attained their normal development. Hence, it is certain that plants, in their earlier stages, respire after the manner of animals, absorbing oxygen and exhaling carbonic acid. These physiological facts were demonstrated by M. Corenwinder, in a memoir published in 1866 by the Société des Sciences of Lille.

III.

It is not alone young plants just produced from the seed or from the bud in the spring that offer these characters: all foliaceous organs, while young, tender, and injected with nitrogenized materials, and just beginning to derive their nourishment from the carbon of the atmosphere, sensibly exhale carbonic acid in the daytime. If we observe the young branches which, during summer, grow on trees of persistent foliage, the *Laurocerasus*, for example, we find that, in these new growths, the phenomenon of respiration predominates: they exhale sensibly carbonic acid in the daytime.

But, if we place under a closed bell-glass an entire branch bearing leaves of the current and of the preceding year, collecting the air that has been in contact with them in a receiver holding baryta-water, and provided with an aspirator, we find that the result varies according to the relative quantities of new and old leaves. If the latter are in excess, they absorb the carbonic acid exhaled by the former, and the baryta-water remains clear, but it grows turbid when the new leaves predominate.

If the experiment be made at the period when all the leaves of the current year have attained their adult age, the branch of *Laurocerasus* gives out no carbonic acid while exposed to light, provided the light is not very feeble.

The point at which plants cease perceptibly to give out carbonic acid in the daytime varies widely according to the species. Corenwinder has found some which exhibit this property for a long time, while others lose it very early. In the first category we may class a perennial plant common in our gardens, *Diclitra spectabilis*, and in the second the young leaves of the beet.

The cause of this peculiarity cannot at present be assigned; certain it is, however, that it largely depends on external circumstances, heat, for instance, which quickens all the chemical actions of oxygen, or the intensity of the light which promotes the assimilation of the carbon. But the special nature of the plant also plays a part. Hence we must not jump at conclusions after one of these experiments, if we would avoid setting up artificial laws with many exceptions.

It was at first difficult to account *a priori* for the fact of this property of nascent plants constantly exhaling carbonic acid, being at the outset very patent, and then diminishing in intensity as they grow, and finally disappearing. But experiments of another kind, described eight years ago by M. Corenwinder, put him on the track of this phenomenon, and gave him a plausible explanation of it.

Adopting the same processes which enabled Bonnet, Ingenhousz, and Sennebier, to lay the foundations of plant physiology, he placed buds and young stems bearing new leaves in bell-glasses filled with spring-water containing bicarbonate of lime or in water charged with carbonic acid, and then exposed them to the sun. As was to be expected, the leaves were soon covered with bubbles, and gave off oxygen; and this is the case even with leaves whose evolution is not yet complete. Hence it is plain that, from the earliest period of their life, plants decompose the carbonic acid of the atmosphere and assimilate its carbon.

Thus the foregoing experiments prove two facts which seem to be contradictory, and which, nevertheless, are simultaneous: 1. Inhalation of oxygen, accompanied with emission of carbonic acid; 2. Absorption of carbonic acid, leading to a discharge of oxygen. Hence, in young plants, there is simultaneity of the two modes of respiration commonly attributed to older plants; but, in the latter, these two modes have different conditions or different organs. This was the starting-point, and it had to be made clear by means of accurate research.

IV.

As we now see, the plant begins, in the early stages of its life, to respire as the animal does, absorbing oxygen, and exhaling carbonic acid. But we have still to inquire why it is that the exhalation of carbonic acid gradually diminishes as the leaves grow in size. This is the great point to settle. Inasmuch as the respiratory organ grows in vitality and in size, it looks as though the respiration ought to become more active, and consequently augment the exhalation of carbonic acid, if this latter process is the respiration.

In order to solve this problem, M. Corenwinder judged it necessary to investigate very closely the variations occurring in the chemical composition of leaves during their vegetation. For this purpose he has made numerous researches, whereof we will describe two experiments made during the summer of 1873, one upon a white lilac, the other upon a maple with fine green leaves. These occupy a good, airy site in the author's garden, near the city of Lille.

M. Corenwinder gathered leaves of these plants at suitable intervals, from April 15th till October 31st, analyzing them afterward to determine the amount of water, nitrogenized substances, ash, and ternary compounds, they respectively contained. In sundry cases, at the most characteristic periods, the proportion of phosphoric acid contained in the ash was accurately weighed.

As every one knows, water forms a considerable portion of the substance of leaves, as much as four-fifths. As a rule, this proportion becomes less as the season advances, and the leaves grow older, but the diminution is not regular. As M. Corenwinder has shown, it needs but to rain for a little while to very sensibly raise again the proportion of water in leaves. These variations in the water of vegetation of leaves make it difficult to compare the other elements which they contain, and hide the relative increase or decrease of each of these elements. De Saussure evaded this difficulty by calculating the leaves in the dry state, and then determining what would be the relative proportions per cent. of the various elements in each leaf, if really deprived of all its water. M. Corenwinder adopts the same course. Having given in full the results of his two series of experiments, he condenses them in the following tables, which enable us easily to follow the evolution of each of the groups of elements in the leaf:

LEAVES OF COMMON LILAC.

1873.	REMARKS.	Nitrogenized Matter.	Carbonaceous Matter.	Ash.
April 15	Leaves small	27.87	67.71	4.42
" 18	" larger, flower-buds just appearing	23.36	71.45	5.19
" 21	" still larger, flower-buds developed	18.00	77.04	4.96
May 12	" normal; flowers expanded	17.86	77.68	4.46
June 6	" " flowers withered	14.75	78.35	6.90
July 1	" "	12.62	79.04	3.34
Aug. 2	" "	10.81	80.79	8.40
Sept. 2	" "	10.31	81.77	8.52
Oct. 1	" still green	11.19	80.61	8.20
" 31	" withered	8.87	83.13	8.00

PHOSPHORIC ACID IN THE ASH.

DATE.	In 100 Parts of Dried Leaves.	In 100 Parts of Ash.
April 15	1.400	31.67
June 6	0.770	11.16
Oct. 1	0.460	5.61
" 31	0.256	3.20

LEAVES OF THE MAPLE.

DATE.	REMARKS.	Nitrogenized Matter.	Carbonaceous Matter.	Ash.
May 1	Leaves small	40.94	53.06	6.00
" 7	" small, expanded	38.56	54.54	6.90
" 20	" larger	26.25	65.86	7.89
June 13	" normal	22.87	67.73	9.40
July 12	" "	20.19	68.17	11.64
Aug. 4	" "	19.59	68.13	12.28
Sept. 3	" "	20.62	65.88	13.50
Oct. 3	" fading	20.00	65.25	14.75
" 14	" fallen	14.80	69.00	16.20

PHOSPHORIC ACID OF THE ASH.

DATE.	In 10 Parts of Dried Leaves.	In 100 Parts of Ash.
May 1	2.797	49.62
June 13	0.957	10.18
Oct. 3	0.119	0.73

It will be at once observed that the absolute amount of nitrogenized substances differs widely as between the leaves of the two plants: there is at first far more in those of the maple than in those of the lilac, and this superiority is maintained during the whole period of vegetation.

Probably were we to examine from this point of view a large number of plants, we should find differences as great as these. Even between trees of the same species similar differences occur, according to their age and vigor, and more particularly according to the surroundings. Thus, on July 12, 1873, M. Corenwinder collected leaves of the common lilac in a garden situated in the open country near Saint-Quentin, and in them found :

Nitrogenized matters	18.56
Carbonaceous matters	72.90
Ash	8.54
	100.00

Comparing this analysis with that of the lilac-leaves which were gathered at the same time, but in a city-garden, we see that those which had plenty of air, growing in the country, remote from aggregations of human beings, are the richer in nitrogenized substances. They also grow thicker and larger, the activity of respiration developing their vitality, and promoting the growth of the organs which discharge that function. Hence it would appear that, for plants, as for animals, an abundant absorption of pure air, rich in oxygen, is the essential condition of a strong, vigorous constitution.

But these individual or specific differences have no importance as regards our problem. The point for us to consider is, not the *absolute* proportion of a given element, but rather the relative modifications which the initial proportion undergoes during the life of the leaf. Let us see what the tables have to say on this point:

1. During the growth of the leaves, the relative proportion of nitrogenized matter in their tissue grows rapidly less. It is at the maximum just when these organs are breaking out of the bud, and it goes on decreasing thenceforward till about the beginning of July, when the fruit of the lilac has been formed. From that time on, the quantity of nitrogenized matters varies but little, though it seems to gain a little in leaves approaching maturity. Finally, it is at the minimum when the process of vegetation is complete.

At the moment of their falling, we find in lilac-leaves only about one-third the amount of nitrogenized matters they contained at the outset. In maple-leaves the amount is relatively greater, but the difference is not very important.

2. If, now, we look at these analyses with respect to the amount of carbonaceous matters, we find that the latter rapidly increases from the moment when the leaves start from the bud, down to the time when they have attained their greatest size, i. e., when they have reached the adult age. As regards the lilac, this is the case when the flowers are ready to expand. The carbonaceous matters thenceforth gain less notably till September; but then we perceive a sensible decrease, especially as regards the maple. Finally, they attain the maximum at the time of falling from the tree, this rise being due to the disappearance of a notable amount of nitrogenized substances.

3. The ash, too, increases rapidly down to June, but then it grows less pronounced. There is relatively a greater amount of mineral matter in the faded leaves of the maple than in those of the lilac. The latter, at the close of their life, show a slight diminution, which is perhaps accidental, in mineral salts: being more tender than maple-leaves, they probably lose a little of their soluble salts under the action of rains.

We have only to compare the mature leaves of the maple with those of the lilac, in order to see that the former must contain more fixed salts than the latter: the fibres which traverse them are thicker, stronger, and more numerous, than in the leaves of the lilac, and hence they are richer in silica and salts of lime.

The ashes of these two trees differ very widely from one another. Even in the same species the quantity of the ash, like that of the nitrogenized matter, differs according to the surroundings, the age of the plant, the humidity of the soil, and the heat to which it is exposed. It was proved by De Saussure that the quantity of ash is much less in nascent leaves than in those which have attained the term of their existence.

4. De Saussure also proved that in the ash of buds and nascent leaves there is more phosphoric acid than is found at any later stage. Since his time this fact has been confirmed by Garreau, of Lille, and by Corenwinder. The present series of experiments furnishes a new demonstration of this important phenomenon.

In the tables we have given the reader will observe that the proportion of phosphoric acid, which at the outset was considerable, especially in the maple-leaves, rapidly grows less, and when the process of vegetation is at an end it is very small indeed. Thus, when coming from the bud, they contain (in the dry state) about .028 phosphoric acid; but at last they contain only about .001. It was long ago proved by M. Corenwinder that the phosphorus contained in plants is an essentially variable quantity. It almost entirely disappears from the tissue of annual plants at the end of their growth, being condensed in the seeds, and ultimately serving to perpetuate the species. In perennial plants, the phosphorus does not go into the seeds merely —it is also diffused through the trunk and the branches; further, it hibernates in the buds, which contain the essential elements of the seed, and which perform the same functions as the latter in the evolution of leaves.

V.

Having now made the experiments tell their story, and described the comparative evolution of the various elements of the leaves during their annual life, let us next see whether these variations in chemical constitution may be coupled together under a theory which shall explain the modifications undergone by the gaseous exhalations of plants at the various stages of their life.

When we study closely the figures relating, for instance, to the maple, we find that, in the first stage of growth the nitrogenized matters are very considerable. Probably they have an organization of their own, and exist independently of the vegetal cells; at all events, they discharge functions which may be called *animal*—they *respire*, and in this early stage respiration is the dominant function. The carbonic acid resulting from this operation is at first only in part retained in the plant by the reducing action of the chlorophyll. The young plant, when exposed to the light and placed in atmospheric air, exhales an excess of carbonic acid.

In the second period, the *relative* proportion of nitrogenized matters grows less, while, on the other hand, the carbonaceous matters increase. The plant now exhales only a small amount of carbonic acid, the latter being almost entirely retained by the chlorophyll, which decomposes it, and fixes its carbon.

Later, the disengagement of carbonic acid ceases, that gas being instantly absorbed by the chlorophyll as soon as it is produced in respiration. The plant has now entered the adult stage. It freely absorbs the carbonic acid of the air, under the influence of the sun's rays, and gives off oxygen. The phenomenon of respiration is at this period completely masked, and cannot be shown to exist except by indirect processes, as we shall soon see.

On reading the column of figures headed "Carbonaceous Matters," we find that, in September, they grow rapidly less. Further, M. Corenwinder has discovered that, toward the beginning of October, the leaves exhaled a little carbonic acid in the daytime. Here the phenomenon is not of the same nature as at the beginning of vegetation: the yellow leaves are dying, and lose their carbon, like all decaying or dead organic matters exposed to the air. When vegetation is at an end, the proportion of carbonaceous matters seems to increase, owing to the rapid disappearance of nitrogenous matters.

From the facts established in the physiological and chemical experiments we have described we derive a very probable explanation of two phenomena, which at first view would seem to be mutually incompatible, viz., exhalation of oxygen and exhalation of carbonic acid. The latter of these has its seat in the nitrogenized matters, and constitutes the respiration of plants, which is henceforth to be esteemed the same as the respiration of animals. The other phenomenon has its seat in the chlorophyll. It has been wrongly held to be a respiratory act: it is, in fact, a true digestion of carbon.

VI.

From what has been said, we may unhesitatingly conclude that leaves in their earliest stage simultaneously perform two physiological functions: 1. They respire by means of their nitrogenous constituents; 2. They assimilate carbon by means of the carbonaceous matters organized in their tissues, i. e., the chlorophyll.

This act of respiration, as we have seen, becomes less apparent as the plant begins to assimilate carbon, but, in reality, it goes on uninterruptedly, being only masked by the increased activity of the other function. That this is the case may be proved experimentally.

In the first place, we know that plants cannot live in an atmosphere without oxygen. When they are placed in close vessels containing hydrogen and nitrogen, they live for a while, owing to the small quantity of atmospheric air in their cells; but yet, though outwardly they may give no sign of decay, on being taken out of the vessels they are found to be dead. The development of the buds ceases utterly in an oxygenless atmosphere. On March 29, 1872, M. Corenwinder placed a chestnut-bud in a test-tube containing atmospheric air, the mouth of the tube being immersed in a solution of caustic potash. The bud formed carbonic acid rapidly, inhaling the oxygen of the air in the tube. The acid was absorbed, as soon as formed, by the alkaline solution, and the latter rose in the tube until there was no gas left except nitrogen.

The bud was kept in the nitrogen till May 2d; it then began to give signs of decay. During all this time it never gained in size, and retained its original form. The conclusion is, that *bud development cannot go on in an atmosphere deprived of oxygen.*

We know, further, from the observations of Th. de Saussure, that germination is impossible when the embryo, in process of growth, does not find, in the atmosphere in which it lives, the amount of oxygen needed for its life. Hence Corenwinder's experiment gives us a fresh instance of the resemblance between germination and the evolution of leaf-axes.

Th. de Saussure also examined several plants placed in an atmosphere of nitrogen. According to their behavior under these circumstances, he divides them into two categories, viz., those which vegetate in such an atmosphere only for a few days, and those which live and even flourish there for a certain length of time. Plants of the latter class are chiefly those which inhabit marshy situations, such as *Lythrum salicaria*, *Epilobium hirsutum*, *Polygonum amphibium*, etc. He has expressed the opinion that plants possessed of this latter property consume less oxygen, vegetating in atmospheric air without much light.

If, in M. Corenwinder's experiments, plants wither rapidly, the reason is, that in the morning he drew off the carbonic acid formed during the night by the agency of the oxygen contained in the cells. When this is not done, the leaves may decompose the acid in the daytime, give out oxygen, and so live for a long time, the oxygen being inhaled and exhaled over and over again.

Finally, if the leaves be kept in absolute darkness, the reducing action is null, and then the act of respiration, which, of necessity, is never completely suspended, alone appears, and the plant disengages only carbonic acid. This function, however, is curiously affected by temperature, so that, at 32° Fahr., leaves usually exhale but little carbonic acid.

These early observations would of themselves suffice to show the existence in plants, at every stage of growth, of a respiratory action, like that of animals, viz., an absorption of oxygen.

What in the books is called the diurnal respiration of plants, is in reality an assimilation of carbon; in other words, it is the act whereby the leaf-organs decompose the carbonic acid of the air, and give out its oxygen. This act depends essentially on the influence of light. It is at the maximum intensity when the plant is under the direct action of the sun's rays, and gradually diminishes in importance in proportion as the light grows feebler; for instance, when the sky is overcast with clouds, and when the weather is thick and rainy. This was demonstrated in a memoir by Corenwinder, published in 1858.

Still, with full-grown leaves in the open air, and with abundance of light, we but rarely find them exhaling even a very small amount of carbonic acid; though—as was shown by M. Corenwinder ten years ago—if we transfer them to a room lighted only by side-windows, and to which the direct rays of the sun do not penetrate, they generally, under these conditions, exhale carbonic acid in the daytime, the proportion varying according to the nature of the plants, the weakness of the diffused light, and the temperature. Of all the plants experimented on in this way by M. Corenwinder, the common nettle appeared to give out the largest amount of carbonic acid, when kept in a room.

These facts M. Corenwinder announced ten years ago, but he did not then venture an interpretation of them, as he does now.

M. Boussingault has shown that leaves placed in a bell-glass containing pure hydrogen mixed with a little carbonic acid, and kept in an ill-lighted room, give off traces of oxygen. This proves that even under the most unfavorable conditions the assimilation of carbon does not entirely cease: this act is completely suspended only in total darkness.

Now, as it is likewise certain that, under the same conditions as to light, leaves kept under a bell-glass *filled with air* give out carbonic acid, and inhale oxygen, it follows inevitably, from these two classes of observations, that the functions inherent in plants, respiration and assimilation of carbon, are simultaneous; *the latter function is, however, reduced to such a degree that it no longer completely masks the effect of the former;* in other words, the chlorophyll can no longer absorb all the carbonic acid produced by respiration.

Here, then, we have a fact analogous to that which we see in the earliest stage of vegetation, with this difference, that in the case of the bud the reducing action is insufficient, owing to the relative inferiority of its carbonaceous matters, while in the other case the insufficiency results from the reduction of their power.

These facts are undoubtedly very strong arguments for the theory of two simultaneous functions in leaves. M. Corenwinder still further confirms it with sundry observations, which are easily made.

Place perfectly green, full-grown maize-leaves under the bell-glass of the apparatus already described, and it will be seen that in the daytime they do not exhale the slightest trace of carbonic acid. If we could deprive these leaves of their green matter, which to all intents and purposes performs the assimilative function, we could doubtless discover the other function which this conceals, viz., respiration. Now, this very experiment Nature makes easy for us. As all are aware, there is a species of maize with striped leaves, which often bears white leaves without a trace of green. If we examine closely the striped leaves, we shall see that their white portions have absolutely no chlorophyll within. This is not the case with the leaves of a purple or of a black color; these, in addition to the coloring matter characteristic of them, contain always more or less green matter, masked. They also possess the property, which the white leaves do not, of absorbing carbonic acid, and exhaling oxygen in a perceptible degree, when exposed to the sun. We lay stress on these phenomena, since it is for want of having understood them that very recent authors describe colored leaves as being usually deprived of the function of assimilation.

If we make the experiment already described with white leaves, we shall find that in the daytime they exhale a perceptible amount of carbonic acid.

Sennebier had observed that the yellow and red stripes of the *Amarantus tricolor* do not give off oxygen when exposed to the sun, but that the leaves of the *Amarantus ruber*, on the contrary, possess this property. So, too, leaves naturally green, which change color at the close of their life, entirely cease from absorbing carbonic acid and exhaling oxygen. Corenwinder has shown that faded leaves that are on the point of falling constantly give out carbonic acid. The fact seems to be universal. Here, however, it is not a phenomenon of vitality that appears, but an act of decrepitude, which goes on and increases after the leaf has fallen.

We observe the same phenomena in other plants, some of whose leaves contain no green matter whatever, especially in the striped maple, which is such an ornament of our gardens in summer. In August, 1868, M. Corenwinder gathered off one and the same maple some leaves that were perfectly white, and others that were perfectly green, and analyzed them to determine the amount of nitrogen they respectively contained, with the following results:

WHITE LEAVES.

Nitrogenized matters in 100 grammes, dried at 212° Fahr.......... 17.06 gr.

GREEN LEAVES.

Nitrogenized matters in 100 grammes, dried at 212° Fahr........... 13.75 gr.

Thus we find a much larger amount of nitrogenous elements in the white leaves than in those which contain chlorophyll; on the other hand, the latter are richer in carbonaceous substances. These two observations clearly confirm M. Corenwinder's theory.

Finally, we may conclude, from all the analyses and experiments we have here detailed, that there exist in plants, at every stage of their life, two distinct functions having different centres of action. The one is *respiration*, which depends upon the nitrogenous organic bodies. The other is assimilation of carbon, which has its seat in special organisms, formed principally, if not exclusively, of ternary elements.

This theory gives a natural explanation of all observations upon the physiology of leaves. M. Corenwinder hopes soon to make an application of it, and will show what it is worth, by explaining, with its aid, the origin of carbon in plants.

FACIAL ANOMALIES.

By Dr. KARL MÜLLER.

I WAS once sitting in a cool underground saloon at Leipsic, while without people were ready to die from the heat, when a new guest entered and took a seat opposite to me. The sweat rolled in great drops down his face, and he was kept busy with his handkerchief, till at last he found relief in the exclamation, "Fearfully hot!" I watched him attentively as he called for a cool drink, for I expected every moment that he would fall from his chair in a fit of apoplexy. The man must have noticed that I was observing him, for he turned toward me suddenly, saying, "I am a curious sort of person, am I not?" "Why?" I asked. "Because I perspire only on the right side." And so it was; his right cheek and the right half of his forehead were as hot as fire, while the left side of his face bore not a trace of perspiration. I had never seen the like, and, in my astonishment, was about to enter into conversation with him regarding this physiological curiosity, when his neighbor on the left broke in with the remark, "Then we are the opposites and counterparts of each other, for I perspire only on the left side." This, too, was the fact. So the pair took seats opposite to each other, and shook hands like two men who had just found each his other half. "Well! this makes an end of natural history," exclaimed another guest, who hitherto had quietly gazed on this strange performance as though it were a play; and every one that had overheard what was said came to look at this novel wonder.

"This makes an end of natural history!" This expression excited me to laughter, and involuntarily I exclaimed: "No, sir, this is just the beginning of natural history; for Nature has many strange caprices even as regards her symmetry. I then mentioned the case of a man I had known in my boyhood, who, Janus-like, had two totally different faces—on one side laughing, on the other crying. Naturally I dreaded this strange double face, with its one side smooth, plump, and comely, like a girl's cheek, while the other side was all scarred by the small-pox. This side of the face denoted churlishness; and, while the other side wore a smile, this boded mischief. In this instance disease had been unsymmetrical.

Seated again in a different place, I mentioned to a friend, a physiologist, the wonderful anomaly I had seen. "Why," said he, "only look at the young Assessor von Th., yonder; he will show you an asymmetry such as you will not meet with every day." Sure enough, this man had a nose which was situated by no means in the middle of his face. I had seen this young man often before, but had never clearly made out what it was in his face that impressed me. Now I saw it at once: it was the man's nose; and since then I have come to see that only a minority of mankind have their noses right in the middle of their faces; and most of us have our noses very much out of place without suspecting it.

But the eyes! Surely, those windows of the soul, can never be charged with asymmetry! I used to think Nature had too correct an æsthetic sense to do such a thing as that. But I know two persons, one of whom, a man, has one eye brown and one blue; the other of them, a woman, has one eye blue and one black—her hair being brown. In such a state of things, all we can say is, that the blending of the two parents is under some conditions not perfect. Strictly speaking, this too is the case where southron and northern, with black hair and blue eyes, or with light hair and black eyes, are still in antagonism, and where consequently the Darwinian force of inheritance is not yet fully established—in other words, where a new race is not yet formed. And, in the face of these facts, what are we to think of the eye as the "mirror of the soul?" Here one eye flashes and threatens, and the other is as mild as the German spring-time, the while only one heart beats and throbs in the bosom. Nay, the heart itself is not always in its own place; it sometimes occupies the right side of the chest. But it is of the eyes I was speaking, and not of the heart. I do not propose to discuss the whole question of the color of the eyes, down to albinism; I would simply observe that, as seen through them, the world wears a very different aspect for different individuals—a circumstance which, however, has nothing to do with asymmetry. Some eyes see only complementary colors, e. g., red instead of green; others see no color at all, every thing appearing to them like a copperplate engraving.

But color, too, has its caprices, as shown in the hair. I once asked an acquaintance why he did not allow his mustache to grow. His reply was, because on one side it was light brown, and on the other white; and he bade me look at his eyebrows, where I would find at least a partial confirmation of what he said. In fact, my friend had not stated the whole truth, for the dualism was faintly discernible even in the hair of his head. When a boy, I knew a whole family, the young members of which had each on the poll one or two locks of white hair. It was but yesterday I discovered, among my Christian neighbors, a descendant of Abraham, having black, curly hair, but blue eyes, and light eyebrows and mustache—the latter being as becoming to its handsome wearer as if his hair had been brown. Clearly a reversion from Western race-mixture to the Oriental type! I am confident that similar anomalies might often be noted if the attention were directed to them.

There are many other facial anomalies, which fail to attract attention, because we have grown accustomed to them. We should expect the convex cast of one side of the face to fit, line for line, into the concave cast of the other; but it is doubtful if there is to be anywhere found one single head of this ideal perfection. Neither the contour of the cheeks, nor the lines of the countenance, are the same on both sides, and they are all the less so because every one unconsciously tends to perform many unilateral facial movements, which in time cause a divergence between the two sides of the face. Besides, the head, projecting as it does freely into air, is more dependent than we imagine on wind and weather. Suppose a person were to sit constantly at a window, turning one side to the cooler atmosphere out-of-doors, and the other toward a hot stove—the result would be a twofold growth of the facial muscles. One side of the face might become rounded, the other flat or concave; and, though such faces are not unfrequent, we do not notice the anomaly, simply because we are accustomed to it. In the Lapp we have a good illustration of this unequal development. Just as the trees of his native land are stunted, so too his features become monstrous, irregular, and one-sided: the frontal bones are forced, as though by spasm, down on the maxillaries, producing the most singular combinations and contortions of the features. A not uncommon form of asymmetry, in more favored lands, is the presence of a dimple on one cheek, while the other has no such indentation, or but a very faint one. In such cases the face has, as it were, a summer and a winter side, just like the apple, which is round and ruddy on its summer side, but on the shade-side flattened and wan.

We are too much inclined to regard these phenomena of asymmetry as merely accidental, whereas the fact is that they are the result of a universal law. Take, for instance, the case where the mustache is longer or thicker on one side of the lip than on the other; the law is everywhere the same: nothing is like any thing else, as Goethe has said. Throughout the entire organic world, and even down to the inorganic creation, down to the world of crystals, nothing that wears a specific form attains the full perfection of that form. I once requested a friend of mine, a mathematician, to reduce to a single formula the curves of an ivy-leaf. He spent weeks in measuring and calculating, but at last gave up the undertaking as an impossibility: no leaf was like another. Indeed, were Nature's forms ideally perfect, the result would be primness rather than beauty. Observe how powerfully the expression of the face is affected by the asymmetry between the upper and lower rows of teeth. The position of the eyes at equal distances on each side of the median line of the face—the nose—might seem to be indispensable for beauty, and yet how very rarely are the eyes placed with perfect symmetry! The wonder is, that these asymmetries of the face should be, after all, so slight as they are, considering how serious are the impediments placed in its way by the requirements of bodily growth. That the two halves of our body should grow so uniformly as they do, except in a very few instances, is the best evidence of the absolute unity of this form of organism, which is based on the vertebral column, and developed along with it.

The arrogant spirit of man revolts against the idea of its so-called bodily shell being a mere natural product, just like every other organized structure; but, for all that, the universal morphological law still remains. Art alone transcends all the requirements of natural production. Where art comes in play, the individual disappears; the contingent gives way before the eternal, the permanent. But this is a harmony that is never attained by Nature.—*Die Natur.*

THE CONFESSION OF A REFORMED SMOKER.

A RECORD OF OBSERVATIONS AND EXPERIMENTS CONCERNING THE PHYSIOLOGICAL ACTION OF TOBACCO.

BY FRANCIS GERRY FAIRFIELD.

IN submitting the following observations as to the physiological effect of smoking, it is not my intention to discuss the tobacco question in an exhaustive manner, but, on the other hand, to limit my remarks to experiments tried and recorded in the course of the year ending July 10, 1874, and to the more general memoranda of the previous twelve years, during which the habit was formed, and, with the exception of brief paroxysms of abstinence, steadily developed. Many will no doubt dissent from the conclusions at which I arrived: to whom I have only to reply that my observations and experiments have not been, save in a cursory memorandum now and then, extended beyond my own person, and represent uniquely the manner in which I have been individually affected by habitual smoking. So far as I have any opinion to express, it consists of induction from actu a l x-periments, and of inferences from actual symptoms; and, if I seem to leave many points undetermined, it must be set down to the fact that they are not within the scope of the particular method I have followed. That tobacco differently affects different temperaments there is no doubt. That different grades and qualities of tobacco differ materially in their physiological action, in manner and symptom, if not essentially, is demonstrated by experiment. In smoking, even, to say nothing of other forms of the tobacco-habit, it makes a material difference whether the same quality is used in conjunction with the pipe or consumed in the form of the cigar—a fact mainly due, no doubt, to the escape of the pyreiline, a base of extreme volatility, in cigar-smoking, and to its conservation to a greater extent in pipe-smoking. Yet, making all due allowances for differences of temperament, for the bias of transmitted habit, and for idiosyncrasies developed by special circumstances, I am constrained to the conclusion that, in the majority of instances, the habit of smoking is productive of nervous degeneracy.

My own case is possibly an extreme one, though not, I am inclined to think, to the extent of vitiating its application to the majority. My father used tobacco. My grandfather on my mother's side, a physician by profession, whose physical and mental traits I inherit to a considerable extent, was a moderate smoker; whether my paternal grandfather used the weed I have no means of ascertaining. I may add, however, that its use is pretty common among the collateral limbs radiating from the family trunk, and that there is hence no reason for regarding the phenomena in my case as the results of constitutional antagonism to the narcotic.

I have been a smoker, or had been up to July, 1874, for thirteen years, having commenced at the age of twenty-two. During the first three years I was somewhat irregular in my habits, sometimes smoking a pipe, sometimes consuming cigars at the rate of from three to five per day, and sometimes refraining altogether for from three days to a week.

I am of cerebro-muscular temperament; of slender *physique*, though broad-shouldered; with great physical endurance conjoined to peculiar sensitiveness of nervous organization, am yet not liable to the nervous excitability generally associated with sensitiveness. Opium and its preparations take their normal narcotic effect in very minute doses, inducing languor and drowsiness within a few minutes after administration. No tendency to talk precedes narcotism, nor is the slightest tendency to fantasy developed by the drug. Hasheesh acts in a manner analogous to morphia, bringing on stupor at the moderate dose, but engendering none of those deliciously intangible sensations which are so generally attributed to its action by Bayard Taylor and others who profess to have experimented with it.

Alcoholic stimulants act limitedly as excitants, but powerfully and rapidly as sedatives. I soon fall asleep under the action of whiskey and brandy. Wines, also, are generally sedative; but ale acts as a stimulant to the brain and nerve-centres with unerring certainty of effect, while its sedative action is long postponed and extremely unreliable. Have never used stimulants habitually, or even with ordinary frequency. Have taken morphine in quarter-grain doses, or the equivalent in laudanum, a dozen times, possibly, in the course of as many years. Am regular in my habits, temperate, and accustomed to protracted intellectual effort; inherit a narcotic tendency from my father, which exhibits itself in peculiar psychical phenomena whenever defective nutrition or protracted nervous tension is permitted.

One idiosyncrasy is worth noting at this stage of the narrative. Although I have smoked habitually for ten years, I have never been able to take tobacco in my mouth without violent nausea, or even to retain a cigar between my teeth; and have always been compelled to remove my cigar frequently from my lips and to carry it between my fingers, when not in actual use. In short, the slightest and most momentary contact of tobacco with the nerves of taste produces instant and uncontrollable nausea, though I am exceedingly fond of smoking, and have always been reckoned a connoisseur in flavors. I should add, however, that offensive sights, as of a person deformed or idiotic, and offensive odors, have the same effect, and instantaneously produce violent nausea.

The physiological effect of tobacco, when I first began to use it, was intense and disagreeable, producing contraction of the pupil of the eye, dizziness, labored breathing, and considerable tendency to spasms; and as these symptoms were more marked with the pipe than with the cigar, in which the pyrieline is mostly disengaged by the surrounding atmosphere, I conclude that they were due in the main not to the nicotine, but to the pyrieline and picoline bases, which are more immediately responsible for the first poisonous action of tobacco-juice when swallowed. Their action is more rapid when taken internally than when subcutaneously injected; and, though substantially identical with that of nicotine, is rather less distinctly narcotic, rather less immediately nervous, and rather more definite in its tendency to produce convulsions. As the nerves become habituated to the narcotic, a state of pleasant and exhilarated reverie, after smoking a few minutes, superseded the more obtrusive symptoms, and lasted sometimes half an hour or more, when languor supervened; and, as the habit became settled, it was accompanied by a mental aura, marked by general tendency to abstraction, and by a dreamy, metaphysical habit of thought. Vague generalizations took the place of real observation in the physical sciences to a greater extent than is compatible with progress in physics. I was intolerant of particulars, and impatient with nicety of discrimination, although I had previously been of extremely analytic habit, and noted in the academy and at college for subtilty as an algebraist. I had my logic of shadows and reveries, and was, withal, a little inclined to mysticism after the German pattern, and to vast theological speculations.

At the same time there was some gain in repose of nerve from the use of the weed, and some trifling gain in mental concentration, particularly as respected the study of Hegel, Schelling, Kant, and the German metaphysicians at large, which happened just then to be in my way. Hegel's *anima mundi* and I were on terms of familiar intimacy, and Schelling's fine discrimination between the different shades of shadows was accepted as really valuable in its contributions to philosophical literature. I mean no disrespect to Hegel and Kant, whose definition of life as self-aim has the merit of brevity, and will, perhaps, by-and-by, have to be incorporated into biology; only generalizing is by so many degrees easier than investigation that men come, I think, sooner or later—some sooner, some later—to have a kind of contempt for mere metaphysical speculation, however imposing its painted bubbles of imagined reality, and to long for a little truth founded on fact, not on mysterious trains of ratiocination, having no basis except an introspective one.

On the other hand, there was some loss of sympathy with life. The actual was hazy and Rembrandtish. Day in and day out I speculated on Hegelian nothings—mere dodges in words—as if they had been underlying principles; and it was not until years after, when the passion for physics had possessed me, that it occurred to me that the *anima mundi* was but an ancient whim under a new name, and that the infinite potentiality which the Hegelists talk about was simply a symbol in nine syllables for something that in plain English (or German) is expressed in one—a gain in grandeur of phrase to be sure, but no real gain in other respects.

That these paragraphs fairly contrast the psychological exponents of the tobacco-habit with the normal condition of my mind, I have been able to satisfy myself by many experiments. By refraining from the use of tobacco for three or four weeks, on a few occasions longer than that, I have returned to the old dramatic sympathy with life; while, by taking up the habit again, I have leaped in a day from the one condition to the other. This experiment I have repeated many times within the past five years, always with the same transition from one series of psychological experiences to the other and very different series. I fancy Nero must have been a smoker, though there is no record of tobacco in those days; for a great deal that passes for firmness, and not a little that passes for cruelty, in this world, is but the apathy of narcotism in its maturer stages. Indeed, it is an open question whether the tobacco-habit was not largely instrumental in engendering the peculiar stoicism of the American Indian and in promoting its culture.

As the process of narcotizing is persisted in, languor attacks the will, there is sinking at the heart on waking up in the morning, the system craves stimulants with a mighty and unappeasable craving, and the motor centres respond but numbly to the motions of consciousness. The incapacity to recollect that marks the advanced stage is clearly the result of languid volition, engendered by torpor of the motor centres.

These symptoms indicate that the great nervo-vital centre, the medulla oblongata, which distributes its forces alike to body and brain, coördinated now as vital phenomena, now as psychical phenomena, is more or less involved, and that vital paralysis is liable to supervene at any juncture. But even at this stage the symptoms yield so rapidly to abstinence as to leave no doubt in my mind that the specific influence of the tobacco is transmitted directly to the great vital tract by means of the pneumogastric nerve. The depressed action of the heart, long before the cerebral centres are involved, points directly to this conclusion, and the augmented gastric and salivary secretions indicate the same avenue of action. The tendency to congestion of the lungs that accompanies the tobacco-habit also sustains this hypothesis; and this may be produced in animals by introducing a very minute dose of decoction of tobacco into the system by way of the mouth, while subcutaneous injection is not equally rapid in producing this special result, nor, indeed, in producing death. Nor have I any doubt, from the few experiments I have tried, and the many I have witnessed, that, in opium-smoking, the peculiar symptoms are occasioned by a similar action of the vapor of the drug (on the medullary tract by way of the pneumogastric nerves). The olfactory nerves are, of course, more or less affected, and transmit the specific influence of either drug directly to the interior lobes of the brain; but experiment and observation alike tend to the conclusion that, though dizziness is somewhat accelerated by this action, it is trifling even in its cerebral effect, and that the great thoroughfare of activity is by way of the pneumogastric. The disturbances in locomotion arising from tobacco are thus secondary effects propagated, not by way of general nervous disturbance, but by direct appeal to the great coördinating centre, the cerebellum, through the near-lying and directly-connected vital tract. The vertiginous symptoms that accompany disturbances of the latter class must not be confounded with those that originate by way of the olfactory nerves, as the whirling sensation is far more marked and distinct in cerebellar disturbances, while the tendency to unconsciousness is somewhat less so.

I am, in these remarks, let it be understood, simply giving the results of my own observations on my own person during the last thirteen years; and my conclusion, from the masses of data thus accumulated, is, that the great sensory and motor tract of gray neurine, known as the cortex, is not at all involved in the primary stages of the narcotism induced by smoking, though the reverse is often clearly true in the instance of opium, with its surer and swifter cerebral effect. Others may be very differently affected by habitual smoking. I simply contribute my leaf to the record; and, although I am not satisfied that the tobacco-habit ever produces neurosis, I am satisfied that it is often the exciting cause of nervous disorder in cases where the neurotic tendency exists, and that in these cases it is productive sometimes of morbid moral phenomena, in a degree only less marked than the epileptic aura, and penetrating to the very roots of volition and ethical emotion. My opportunities for observation in hospitals and asylums have not been extensive enough to permit me to pronounce definitely on the point I am about to suggest; but it is my impression that the larvated type of epilepsy occurs more frequently than any other among persons addicted to tobacco, and that the habit is very generally influential in the larvation of nervous maladies. Statistics only can settle this issue, which must be left to the consideration of medical psychologists.

In order that the lay reader may clearly apprehend the various bearings of the facts, and the intimate relation of the diverse symptoms to each other in tobacco-sickness, it is, perhaps, necessary to map out the pneumogastric nerve and indicate its function, which is not fairly deducible from its name. The origin of nearly every pair of cranial nerves has been traced into the vital bulb, the medulla oblongata, or continuation and expansion of the spinal cord as it passes into the cranium, to blossom into the complex structure of the brain. This tract enters the cranium in six bodies, united in a bulb, and continuing the six strands of the marrow, namely—the two pyramidal continuing the anterior white strands of the spinal stem, the two olivary the interior and partly lateral strands of gray neurine, and the two restiform (corpora restiforma) the posterior white strands. There are two ways of dissecting a brain, each of which has merits of its own for special purposes. The first and more general consists in examining the encephalic mass from above downward, by removing it in successive slices. For descriptive anatomy, and for pathological examination, this method is perhaps preferable. The second consists in examining and unraveling the structure from the spinal bulb upward, by tracing its fasciculi as they expand, radiate, and enlarge; and I am inclined to think that this method has its advantages in tracing the genesis of psychical phenomena. To this bulb all the complex activities of the cerebro-spinal axis finally refer themselves: it is properly the calyx from which spring the three ganglionic masses—the mesocephale, cerebellum, and cerebrum. The par vagum, generally known as the pneumogastric nerves, spring laterally from this bulb, and properly include three pairs of nerves, namely—the glosso-pharyngeal, which supply the base of the tongue with sensation, and connect and coördinate the motions of the organ with those of the pharynx and of the digestive function; the pneumogastric, which, with the preceding, have their origin in filaments springing from the groove between the olivary and restiform bodies; lastly, the spinal accessory, originating laterally from the medulla spinalis, but joining the main stem near its ganglion, and distributed to the lateral muscles of the neck. From the cervical tract of this nerve, which is triple in its origin, spring filaments or strands that join the sympathetic and lingual nerves, others that proceed directly to the pharynx, and still others known as its cardiac ramifications. The superior laryngeal nerve, distributed to the upper portion of the larynx, and the recurrent nerve, distributed to the muscles of the larynx, are both portions of the pneumogastric system. This pair of nerves passes through the jugular foramen just anterior to the vein of the same name, and separates into three parts. In the foramen it presents a ganglionic expansion, and below it a long gangliform swelling which communicates with the facial, spinal accessory, sympathetic, glosso-pharyngeal, and superior spinal nerves—all of which are here gathered into a kind of elongated plexiform bundle. At this point the nerve has the compact-ness and grayish tint of the ganglion. The pneumogastric portion now descends, passing before the lingual nerve and the jugular vein for a little distance, then behind, inclosed in the sheath of the carotid artery and jugular, rather closer to the vein than to the artery, to which it gives off filaments. The importance of this system will be evident when it is stated that it is principally concerned in the coördination of the functions of deglutition, articulation, respiration, circulation, and digestion. The three great functions of animal life, nutrition, respiration, and circulation, are, in briefer terms, mainly coordinated by the par vagum in its cervical, thoracic, and abdominal tracts. With the former and its filaments, and to a considerable degree with the thoracic, the specific influence of the tobacco has, in smoking, a contact exceedingly direct and protracted; and, if the general reader will trouble himself to map out in his own imagination the course, ramifications, and connections, of the pneumogastric system, he will see clearly that the congeries of symptoms occasioned by the initial cigar follows out, step by step, the complex relations of this tract to the vital functions, and that the physical and psychological exponents of the habit in its established stages are, similarly, the natural results of narcotism of this system, and of the great vital centre from which it springs.

To these general facts of observation let me now append the details of a series of experiments:

I had been an inveterate smoker for eight years, when, in the summer of 1872, certain symptoms resembling those of writer's cramp attacked the right arm, and gradually, though to a less alarming extent, enveloped the left. Physicians pronounced it a genuine case of writer's cramp; but, owing to the persistent absence of certain symptoms, among them brittleness and want of color in the finger-nails, I was slow to accept the conclusion. There was reason enough why excessive scribbling should bring on the affection; but I was, nevertheless, doubtful, though I so far complied with the prescription as to have recourse to the ordinary electrical appliances insisted upon by Dr. Poore, in his admirable essays on the subject, which embody, in brief form, the memoranda of an expert of some years' practice.

As I half anticipated, the application was without material benefit. Tonics and nervines proved equally inefficacious, and for a year, with short intervals of relief, affairs did but get worse and worse. Blue ink, elastic pen-holders, and broad-nibbed pens, were altogether incapable of ameliorating the affection or mending the scrawling, irregular handwriting that resulted from it; and so essential is it that the hand and mind should work together in a kind of rhythm, in order to form a good style, or to preserve it when formed, that any affection of the nerves of the arm that breaks up this rhythm is nearly as fatal to the poet, essayist, and novelist, as to the artist or the pianist; and I soon found my sentences as cramped and dissonant as my manuscript.

In October, 1873, I started for the country on a brief furlough, having served through the heat of the summer as a member of the staff of the *Evening Post*, and, not finding the tobacco to my liking, was forced to be exceedingly temperate for several weeks. Slowly, yet perceptibly, the affection of the arms wore off. The hand and forearm were less numb when I woke up in the morning, and my handwriting began to assume its former continuity. This I attributed at first to rest, fresh air, and freedom from worry—an error in the main, as will presently appear, though a very natural one under the circumstances.

I had been at home four or five weeks when I succeeded in supplying my commissary department with a sufficiency of the weed of the required quality, in the mean time smoking a little undoctored Connecticut leaf, when the craving became too strong to be comfortably resisted, but consuming, probably, less than two ounces a week. Upon resuming my usual quantum, and within twenty-four hours after the resumption, my arms were as troublesome as ever, and no rest in the least availed to soften the shooting pains or dissipate the numbness (penetrated as if with lances of neuralgia) that enveloped the arm from the wrist to the shoulder. I was thoroughly dispirited, and contemplated shifting my profession and applying for admission to the bar. I did not yet suspect the relation between the tobacco-habit and the malady under which I was suffering.

Remaining in the country, however, longer than I at first intended, my supply of the weed ran out; and I was again reduced to vulgar rations of Connecticut leaf, of which I consumed the smallest quantity possible. The consequence was an immediate reduction of the pain and numbness in my arms. In the course of this somewhat intermittent use of the narcotic, I observed also that a certain cloudiness of recollection, and a slight tendency to aphasia—the latter due, probably, to action on the lingual nerve—followed the resumption of the full dose after an interval of abstinence, the former interfering materially with the opulence of illustration necessary to a good style, the latter annoying me now and then with slips of the tongue in ordinary conversation.

At this stage of the investigation, with the barest suspicion in my mind that tobacco was responsible for most of the ills my flesh had fallen heir to, or rather my nerves, I returned to New York in the latter part of December, and initiated a series of experiments, with a view to test the physiological action of the various brands, and to verify or disarm the suspicion.

December 26th.—Procured a quantity of Cuban tobacco known as Honradez, an extremely fine brand, and put myself on a ration of half an ounce per day. Continued this regimen for twelve days, without perceptible alteration in the symptoms so far as my arms were concerned.

29th.—After three days of Honradez regimen, slight tendency to tremor and sleeplessness, with exceeding dryness of the membrane lining the nose.

January 1st.—Accelerated tendency to tremor and sleeplessness. Went to bed at eleven o'clock, but did not finally lose myself until after the clock struck one; then wandered off into dream-land instead of dropping to sleep in the normal way. Dreams of a queer, trance-like cast, with occasional starts. (I should interpolate here that I usually fall asleep very quickly after going to bed, and sleep very soundly.)

4th.—Augmented tendency to tremor and sleeplessness, with occasional *secousses* of the limbs. Arms still as benumbed as ever, but with an uncomfortable tendency to jerk. Went to bed at eleven o'clock, but lay awake till after the clock struck three; then fell into a fitful but trance-like slumber.

5th.—Came out of my drowse by slow degrees, and breakfasted about ten o'clock. Irritable and peevish. Tried to write after breakfast, but my hand was too shaky. Smoked a pipe of Honradez, which seemed to subdue the tremor.

7th.—Increased tremor and sleeplessness. Went to bed as usual at eleven, but could not sleep. Took an anodyne (bromide of potash) at half-past three o'clock, and slept soundly until eleven the next morning.

I now increased the ration of Honradez to three-fourths of an ounce per day, with an intensification of the symptoms so rapid and determinate as to leave no doubt of their origin. I was wild with nervousness, yet could not sleep soundly, and invariably woke up in the morning with a more or less pronounced pain in the region of the corpora striata (across the forehead) shooting downward and backward to the base of the brain; but the symptoms were still limited to the motor tract (the corpora striata and its connections), and there were no perturbations of the sensory.

Weighed 121 lbs. 3 oz. when I commenced the experiment, and 120 lbs. 2½ oz. when it was concluded. It should be unnecessary to add that a carefully-regulated dietetic regimen accompanied the experiments from beginning to end, securing at once fullness and variety of nutrition.

11th.—Refrained altogether from the use of tobacco. Fell asleep several times during the day. Went to bed at a quarter before eleven, and was asleep before the clock struck. Slept, with occasional whiffs of dream, until half-past eight in the morning. Continued to abstain for ten days, the nervous system gradually recovering its tone, and the hours of sleep slowly retracting until they fell to a trifle less than eight. An increased craving for food, and relish for it, followed the first day's abstinence, and on the morning of January 12th I ate my broiled steak and drank my cup of coffee with a relish to which I had long been a stranger. The longing for tobacco did not recur strongly until the third day, when it was so importunate that, had I not been trying an experiment, it would have triumphed over all scruples.

Mentally, during the ten days, I was as one coming to himself after a long drowse—an Epimenides recovering from weeks of trance; and, after the third day, during which I suffered from a dull, continuous pain at the base of the brain, in the medullary rather than the cerebellar region, the numbness began to disappear from the arms, which continued to improve pending the progress of the experiment.

21*st.*—Weighing 122 lbs. 6 oz., put myself on an allowance of three Reina Victoria (Regalia) cigars per day, one after each meal, and continued the regimen for ten days, with the same general result that had followed the pipe and Honradez regimen, but somewhat less marked in its nervousness and tendency to tremor.

31*st.*—Weighed 120 lbs. 15 oz., and smoked my last Reina Victoria.

February 1*st.*—Commenced another ten days of abstention, with recovery from the symptoms, at the expiration of which my weight was 122 lbs. 13 oz.

11*th.*—Placed myself on an allowance of a quarter of an ounce perique per day. The first day I suffered from dizziness after smoking, and from slight nausea while in the act. These symptoms disappeared on the second day. The use of this tobacco (a strong Louisiana variety) was not attended with the marked tendency to tremor and sleeplessness incident to Honradez, but with a marked narcotism of the motor tract, and a marked vital depression—the specific action, no doubt, of its excess of nicotine on the great nervo-vital centre, the medulla oblongata. On the fourth day a peculiar sinking at the heart kept me in bed half an hour later than usual in the morning, but a cup of strong coffee taken in bed dissipated the lassitude and restored the vital energy. The numbness in my arms grew more and more pronounced every day, until it required some minutes in the morning with the flesh-brush to readjust the circulation; and with this came a tendency of the legs to fall asleep, showing obstructed nervous circulation, to be followed, in the nature of things, by defective nutrition and ultimate paralysis. During the last two days of the experiment the vital depression became so oppressive that I resorted to brandy in doses of a tablespoonful three times a day. Lost 1 lb. 11½ oz. during the experiment.

Discarding the perique, with its excess of the nicotine, I now limited myself to three pipes of Honradez per day, with a resultant consumption of two ounces a week. This regimen I maintained until the first of April, when I put myself on a daily allowance of a quarter of an ounce of Virginia cavendish; but the vital depression was so rapid that I desisted from the experiment after four days of lassitude.

April 10*th.*—Left New York for the country a thorough valetudinarian; and, after abstaining for a few days, with a rapid recovery from the symptoms, commenced to smoke a specific allowance per day of Connecticut, four pipes in fact, which I continued until the first of June, with less vital depression than was produced by perique and cavendish, but with a distinct tendency in that direction, and with a more marked cloudiness of recollection than had followed either.

June 1st.—Withdrew the allowance of leaf and commenced to smoke irregularly an occasional cigar, scarcely one per day on the average, and to note the effect. The vital depression consequent upon a single cigar was often so great as to compel resort to quinine in two-grain doses. Finally, discarded the habit altogether, with sufficient benefit to the arms to assure me that the symptoms were contingent on the use of tobacco. The numbness had almost disappeared in three weeks of abstinence; I began to wake up refreshed in the morning, not in a vital swoon. My weight, July 10th, was 125 lbs. 3 oz., and I regarded myself as thoroughly convalescent of the habit, though still a Laocoon struggling with his serpents. A violent agitation of the mucous membrane lining the nose has, I should have stated in its proper place, attended every withdrawal of the narcotic, supervening on the second day. The throat has also been considerably affected at these crises, and all the phenomena of a violent cold have been brought on in a few hours; but whether these effects have been mainly due to the withdrawal of the heat evolved in smoking, or to recovery of the membrane from local narcotism, or whether in part to both, I cannot venture to say.

Omitting all details of analysis of different tobaccos as too familiar for repetition, my experiments have led me to conclude:

1. That nicotine is the special agent concerned in vital paralysis and in disturbances of muscular coördination, and that its action upon the medullary centres is propagated by way of the pneumogastric nerve; that the cerebellar centres (coördinating the muscles concerned in locomotion), and the corpora striata (or great motor ganglia of the cerebrum), are next affected; in other words, that the motor tracts follow the vital in yielding to the influence of the poison.

2. That the cortex of the brain is the last to be affected by nicotine, but is more specifically affected by the pyrieline, picoline, and collidine bases. Hence the difference in physiological action between Honradez, with its minimum of nicotine, and perique and cavendish, with their excess; also the analogous difference between Havana cigars and cigars manufactured from Connecticut leaf.

3. That smoking is often the exciting cause of the various neuroses, and always a fruitful source of local aneurism, by impairing the nervous circulation and laying the foundation for defective nutrition in various directions. Cessation from tobacco should be made a condition precedent to medical treatment in writer's cramp and nervous affections of that type (the paralytic).

I am not going to take any radical ground on the tobacco question in its general aspects. Every man must judge for himself, and experiment for himself, as to the physiological action of the weed. I have simply recorded my own experiences and experiments, and the conclusions to which they have impelled me. I will not even say that I shall never smoke another cigar, for temptations are often strong and sudden; but I will say that, in such an event, I should regard myself as the victim of a nervous infirmity, not as one merely indulging himself in a harmless and pleasant luxury—of a devil far easier to get out of the bottle, to apply a Moslem legend, than to get back and cork in again.

WOMAN SUFFRAGE AS AFFECTING THE FAMILY.[1]

By J. E. CAIRNES,

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I NOW turn to a side of the question on which Mr. Smith lays very great stress, and of which I am not in the least disposed to underrate the importance—the extension of the suffrage to married women. I do not yield to Mr. Smith, or to any one, in the firmness of my conviction that the family is at the bottom of our existing civilization, and I should, for my part, regard as dearly purchased any gain in material or political well-being which should introduce a jar or weakness into this pivot of our social system. But I believe that to open political life to women, far from being fraught with the disastrous consequences Mr. Smith anticipates, would, taking things in their entire scope, be productive of quite opposite effects. If I were asked to name the principal element of weakness in the family as things now stand, I should have no hesitation in pointing to the want of sufficient subjects of common interest between man and woman. It is owing to this that matrimonial engagements are entered into so rarely on the basis of any broad intellectual sympathy, such as might furnish some security for lasting affection, and so often at the bidding of impulses and fancies that do not outlive the honey-moon; and it is owing to the same cause that so very large a proportion of the lives of most husbands and wives are spent practically apart, with little or no knowledge on the part of either of the objects or aims that engross the greater portion of the other's thoughts and energies. That under such circumstances the marriage-tie is, on the whole, maintained as well as it is, seems rather matter for wonder; and to argue that the introduction of a new source of very profound common interest for husband and wife must of necessity weaken the bond, is, in my opinion, to

[1] Extracted from an article in *Macmillan's Magazine* for September, in reply to Goldwin Smith.

evince a singular inability to appreciate the real dangers now besetting the institution. It is true, no doubt, that every new subject of common interest for husband and wife must, from the nature of the case, constitute also a new possible occasion for disagreement; but, if this is to be accounted a good reason for excluding women from politics, they might with equal justice be excluded from literature, from the fine arts, from every thing in which men also take an interest—above all, from religion. The value of these several pursuits as bonds and cements of married life is just in proportion to the degree of common interest which husbands and wives take in them, and just in the same proportion also is the possible danger that they may become the grounds of dissension. Mr. Smith is greatly scandalized at the prospect of a man and his wife taking opposite sides in politics. I cannot see that it would be at all more scandalous than that a man and his wife should take opposite sides in religion—going, for example, every Sunday to different places of worship, where each hears the creed of the other denounced as soul-destroying and damnable. It will serve to throw light upon the present problem if we consider for a moment how it happens that this latter spectacle is on the whole so rarely presented, and that, even where the event occurs, it is so frequently found consistent with tolerable harmony in married life. The explanation, I have no doubt, is of this kind: where difference of religion consists with matrimonial happiness, it will generally be found that one or both of the partners do not take a very deep interest in the creeds they profess; while, on the other hand, where people do feel strongly on religion, they generally take care, in forming matrimonial alliances, to consort with those who, on fundamental points, are of the same opinion with themselves. Now, it seems to me that this may serve to illustrate for us what will be the practical working of politics in respect to married life when women begin to receive a political education, or at least to learn as much about politics, and take as much or as little interest in them, as men do. A number only too large of men and women will probably continue for long enough to take but small interest in public affairs, and these will marry, as they do now, with little reference to each other's political opinions; but the danger of discord from politics under such circumstances would be infinitesimal. The only cases in which this danger would become serious would be when both husband and wife were strong politicians. Here, no doubt, there would be danger; though no greater, I think, than when two persons of strong but opposite religious convictions enter into marriage. Mr. Smith seems to think that, because "religion is an affair of the other world," it is less likely than politics to be an occasion of strife. This is probable enough when people do not believe in another world; but when they do, and believe also that the fate of people there will depend on what they believe in this, I cannot see the wisdom of his remark. Some of the worst and cruelest wars that have ever been waged have been religious wars; and so notoriously is religion an engenderer of strife, that it is now scarcely good manners to moot a religious question in private society, where politics are quite freely and amicably discussed. If persons of genuine but different religious opinions can contrive to get on together in married life, they would certainly not be likely to be severed by political differences, however strongly their opinions might be held. But, however this may be, my argument is that, in practice, such cases would very rarely occur. When politics became a subject of interest alike for men and women, it would very soon become a principal consideration in determining matrimonial alliances. Even now this is the case to some extent, and it will no doubt become more and more so as the political education of women advances. Mr. Smith's question, therefore, "Would the harmony of most households bear the strain?" may be answered by saying that in very few households would there be any strain to bear; while in most—at least in those in which politics were intelligently cultivated—home-life, no longer the vapid thing it is so often now, would acquire a new element of interest, and the family would be held together by powerful sympathies that now lie undeveloped.

Mr. Smith seems to think that, if women are only excluded from the suffrage, the harmony of married life can never be endangered by politics; but this is to attribute to the mere right of voting a degree of efficacy which I, for one, am not disposed to allow to it. If women only come to take an interest in politics—it matters not whether they have the suffrage or not—all the danger that can arise from the suffrage to married life will be already incurred. It is not the giving of a vote every four or five years that constitutes the danger, if danger there be; but the habitual mental attitude of husband and wife toward each other. Those, therefore, who share Mr. Smith's apprehensions on the present subject, ought clearly to take their stand against the suffrage movement very much higher up. They ought to oppose every extension of female education which may reasonably be expected to lead women to take an interest in politics. The intelligent study of history should, in the first place, be rigidly proscribed. Political economy would be excluded as a matter of course; and, along with it, that large and increasing class of studies embraced under the name "social." Every one of these, intelligently cultivated, leads inevitably, where faculty is not wanting, to an interest in contemporary politics; and if women are to be shut out from this field of ideas, lest perchance they should adopt opinions which should not be those of their future husbands, their education ought at once to be truncated by this large segment. Mr. Smith, indeed, suggests that women who are capable of discussing political questions "will find a sphere in the press." Does he then suppose that there would be less danger to the harmony of married life from women writing in the press—writing leaders, perhaps, for strong party papers—than from tendering a vote at the polls every four or five years? Besides, the suggestion falls utterly short of the requirements of the case. The number of women who are capable, or who desire, to find a sphere in the press are never likely to be more than a handful: the number who desire a liberal education, in the best and broadest sense of that word, and who are or may become quite fitted to form sound opinions on political questions, are already to be numbered by thousands, perhaps I might say by tens of thousands: what their numbers will become in another generation, I will not pretend to conjecture. Mr. Smith's suggestion, therefore, though graciously meant, is hardly to the purpose. Plainly, nothing short of lopping off from the education of women some of the most important branches of human knowledge will meet the difficulty.

JOSEPH PRIESTLEY.[1]

By T. H. HUXLEY, LL. D., F. R. S.

If the man to perpetuate whose memory we have this day raised a statue had been asked on what part of his busy life's work he set the highest value, he would undoubtedly have pointed to his voluminous contributions to theology. In season and out of season, he was the steadfast champion of that hypothesis respecting the Divine nature which is termed Unitarianism by its friends and Socinianism by its foes. Regardless of odds, he was ready to do battle with all comers in that cause; and, if no adversaries entered the lists, he would sally forth to seek them.

To this, his highest ideal of duty, Joseph Priestley sacrificed the vulgar prizes of life, which, assuredly, were within easy reach of a man of his singular energy and varied abilities. For this object he put aside, as of secondary importance, those scientific investigations which he loved so well, and in which he showed himself so competent to enlarge the boundaries of natural knowledge and to win fame. In this course, he not only cheerfully suffered obloquy from the bigoted and the unthinking, and came within sight of martyrdom, but bore with that which is much harder to be borne than all these—the unfeigned astonishment and hardly disguised contempt of a brilliant society, composed of men whose sympathy and esteem must have been most dear to him, and to whom it was simply incomprehensible that a philosopher should seriously occupy himself with any form of Christianity.

It appears to me that the man, who, setting before himself such an

[1] An Address delivered on the occasion of the presentation of a statue of Priestley to the town of Birmingham, August 1, 1874. With some additions.

ideal of life, acted up to it consistently, is worthy of the deepest respect, whatever opinion may be entertained as to the real value of the tenets which he so zealously propagated and defended.

But I am sure that I speak not only for myself, but for all this assemblage, when I say that our purpose to-day is to do honor, not to Priestley, the Unitarian divine, but to Priestley, the fearless defender of rational freedom in thought and in action; to Priestley, the philosophic thinker; to that Priestley who held a foremost place among "the swift runners who hand over the lamp of life,"[1] and transmit from one generation to another the fire kindled, in the childhood of the world, at the Promethean altar of Science.

The main incidents of Priestley's life are so well known that I need dwell upon them at no great length.

Born in 1733, at Fieldhead, near Leeds, and brought up among Calvinists of the straitest orthodoxy, the boy's striking natural ability led to his being devoted to the profession of a minister of religion; and, in 1752, he was sent to the Dissenting academy at Daventry—an institution which authority left undisturbed, though its existence contravened the law. The teachers under whose instruction and influence the young man came, at Daventry, carried out to the letter the injunction to "try all things; hold fast that which is good," and encouraged the discussion of every imaginable proposition with complete freedom, the leading professors taking opposite sides; a discipline which, admirable as it may be from a purely scientific point of view, would seem to be calculated to make acute rather than sound divines. Priestley tells us, in his "Autobiography," that he generally found himself on the unorthodox side: and as he grew older, and his faculties attained their maturity, this native tendency toward heterodoxy grew with his growth and strengthened with his strength. He passed from Calvinism to Arianism; and finally, in middle life, landed in that very broad form of Unitarianism by which his craving after a credible and consistent theory of things was satisfied.

On leaving Daventry, Priestley became minister of a congregation, first at Needham Market and secondly at Nantwich; but whether on account of his heterodox opinions, or of the stuttering which impeded his expression of them in the pulpit, little success attended his efforts in this capacity. In 1761 a career much more suited to his abilities became open to him. He was appointed "tutor in the languages" in the Dissenting academy at Warrington, in which capacity, besides giving three courses of lectures, he taught Latin, Greek, French, and Italian, and read lectures on the Theory of Language and Universal Grammar, on Oratory, Philosophical Criticism, and the Civil Law. And it is interesting to observe that, as a teacher, he encouraged and cherished, in those whom he instructed, the freedom which he had

[1] "Quasi cursores vitaï, lampada tradunt."—LUCRETIUS, "*De Rerum Nat.*," ii., 78.

enjoyed, in his own student days, at Daventry. One of his pupils tells us that—

"At the conclusion of his lecture, he always encouraged his students to express their sentiments relative to the subject of it, and to urge any objections to what he had delivered, without reserve. It pleased him when any one commenced such a conversation. In order to excite the freest discussion, he occasionally invited the students to drink tea with him, in order to canvass the subjects of his lectures. I do not recollect that he ever showed the least displeasure at the strongest objections that were made to what he delivered, but I distinctly remember the smile of approbation with which he usually received them: nor did he fail to point out, in a very encouraging manner, the ingenuity or force of any remarks that were made, when they merited these characters. His object, as well as Dr. Aikin's, was, to engage the students to examine and decide for themselves, uninfluenced by the sentiments of any other persons." [1]

It would be difficult to give a better description of a model teacher than that conveyed in these words.

From his earliest days, Priestley had shown a strong bent toward the study of Nature; and his brother Timothy tells that the boy put spiders into bottles to see how long they would live in the same air—a curious anticipation of the investigations of his later years. At Nantwich, where he set up a school, Priestley informs us that he bought an air-pump, an electrical machine, and other instruments, in the use of which he instructed his scholars. But he does not seem to have devoted himself seriously to physical science until 1766, when he had the great good fortune to meet Benjamin Franklin, whose friendship he ever afterward enjoyed. Encouraged by Franklin, he wrote a "History of Electricity," which was published in 1767, and appears to have met with considerable success.

In the same year, Priestley left Warrington to become the minister of a congregation at Leeds; and here, happening to live next door to a public brewery, as he says—

"I at first amused myself with making experiments on the fixed air which I found ready made in the process of fermentation. When I removed from that house I was under the necessity of making fixed air for myself; and, one experiment leading to another, as I have distinctly and faithfully noted in my various publications on the subject, I by degrees contrived a convenient apparatus for the purpose, but of the cheapest kind.

"When I began these experiments I knew very little of *chemistry*, and had, in a manner, no idea on the subject before I attended a course of chemical lectures, delivered in the academy at Warrington, by Dr. Turner, of Liverpool. But I have often thought that, upon the whole, this circumstance was no disadvantage to me; as, in this situation, I was led to devise an apparatus and processes of my own, adapted to my peculiar views; whereas, if I had been previously accustomed to the usual chemical processes, I should not have so easily thought of any other, and, without new modes of operation, I should hardly have discovered any thing materially new." [2]

[1] "Life and Correspondence of Dr. Priestley," by J. T. Rutt, vol. i., p. 50.

[2] "Autobiography," §§ 100, 101.

The first outcome of Priestley's chemical work, published in 1772, was of a very practical character. He discovered the way of impregnating water with an excess of "fixed air," or carbonic acid, and thereby producing what we now know as "soda-water"—a service to naturally, and still more to artificially, thirsty souls, which those, whose parched throats and hot heads are cooled by morning draughts of that beverage, cannot too gratefully acknowledge. In the same year Priestley communicated the extensive series of observations which his industry and ingenuity had accumulated, in the course of four years, to the Royal Society, under the title of "Observations on Different Kinds of Air"—a memoir which was justly regarded of so much merit and importance, that the society at once conferred upon the author the highest distinction in their power, by awarding him the Copley Medal.

In 1771 a proposal was made to Priestley to accompany Captain Cook in his second voyage to the South Seas. He accepted it, and his congregation agreed to pay an assistant to supply his place during his absence. But the appointment lay in the hands of the Board of Longitude, of which certain clergymen were members; and whether these worthy ecclesiastics feared that Priestley's presence among the ship's company might expose his majesty's sloop Resolution to the fate which aforetime befell a certain ship that went from Joppa to Tarshish, or whether they were alarmed lest a Socinian should undermine that piety which, in the days of Commodore Trunnion, so strikingly characterized sailors, does not appear; but, at any rate, they objected to Priestley, "on account of his religious principles," and appointed the two Forsters, whose "religious principles," if they had been known to these well-meaning but not far-sighted persons, would probably have surprised them.

In 1772 another proposal was made to Priestley. Lord Shelburne, desiring a "literary companion," had been brought into communication with Priestley by the good offices of a friend of both—Dr. Price—and offered him the nominal post of librarian, with a good house and appointments, and an annuity in case of the termination of the engagement. Priestley accepted the offer, and remained with Lord Shelburne for seven years, sometimes residing at Calne, sometimes traveling abroad with the earl.

Why the connection terminated has never been exactly known, but it is certain that Lord Shelburne behaved with the utmost consideration and kindness toward Priestley; that he fulfilled his engagements to the letter; and that, at a later period, he expressed a desire that he should return to his old footing in his house. Probably enough the politician, aspiring to the highest offices in the state, may have found the position of the protector of a man, who was being denounced all over the country as an infidel and an atheist, somewhat embarrassing. In fact, a passage in Priestley's "Autobiography," on the occasion of the publication of his "Disquisitions relating to Matter and Spirit," which took place in 1777, indicates pretty clearly the state of the case:

"(126.) It being probable that this publication would be unpopular, and might be the means of bringing odium on my patron, several attempts were made by his friends, though none by himself, to dissuade me from persisting in it. But being, as I thought, engaged in the cause of important truth, I proceeded without regard to any consequences, assuring them that this publication should not be injurious to his lordship."

It is not unreasonable to suppose that his lordship, as a keen, practical man of the world, did not derive much satisfaction from this assurance. The "evident marks of dissatisfaction," which Priestley says he first perceived in his patron in 1778, may well have arisen from the peer's not unnatural uneasiness as to what his domesticated but not tamed philosopher might write next, and what storm might thereby be brought down on his own head; and it speaks very highly for Lord Shelburne's delicacy that, in the midst of such perplexities, he made not the least attempt to interfere with Priestley's freedom of action. In 1780, however, he intimated to Dr. Price that he should be glad to establish Priestley on his Irish estates; the suggestion was interpreted as Lord Shelburne probably intended it should be, and Priestley left him, the annuity of £150 a year, which had been promised in view of such a contingency, being punctually paid.

After leaving Calne, Priestley spent some little time in London, and then, having settled in Birmingham, at the desire of his brother-in-law, he was soon invited to become the minister of a large congregation. This settlement Priestley considered at the time to be "the happiest event of his life." And well he might think so, for it gave him competence and leisure; placed him within reach of the best makers of apparatus of the day; made him a member of that remarkable "Lunar Society" at whose meetings he could exchange thoughts with such men as Watt, Wedgewood, Darwin, and Boulton; and threw open to him the pleasant house of the Galtons of Barr, where these men, and others of less note, formed a society of exceptional charm and intelligence.[1]

[1] *See* "The life of Mary Anne Schimmelpenninck." Mrs. Schimmelpenninck (*née* Galton) remembered Priestley very well, and her description of him is worth quotation: "A man of admirable simplicity, gentleness, and kindness of heart, united with great acuteness of intellect. I can never forget the impression produced on me by the serene expression of his countenance. He, indeed, seemed present with God by recollection, and with man by cheerfulness. I remember that, in the assembly of these distinguished men, among whom Mr. Boulton, by his noble manner, his fine countenance (which much resembled that of Louis XIV.), and princely munificence, stood preëminently as the great Mæcenas; even as a child I used to feel, when Dr. Priestley entered after him, that the glory of the one was terrestrial, that of the other, celestial; and utterly far as I am removed from a belief in the sufficiency of Dr. Priestley's theological creed, I cannot but here record this evidence of the eternal power of any portion of the truth held in its vitality."

But these halcyon days were ended by a bitter storm. The French Revolution broke out. An electric shock ran through the nations; whatever there was of corrupt and retrograde, and, at the same time, a great deal of what there was of best and noblest, in European society, shuddered at the outburst of long-pent-up social fires. Men's feelings were excited in a way that we in this generation can hardly comprehend. Party wrath and virulence were expressed in a manner unparalleled, and it is to be hoped impossible, in our times; and Priestley and his friends were held up to public scorn, even in Parliament, as fomenters of sedition. A "Church-and-King" cry was raised against the Liberal Dissenters; and in Birmingham it was intensified and specially directed toward Priestley by a local controversy, in which he had engaged with his usual vigor. In 1791 the celebration of the second anniversary of the taking of the Bastile by a public dinner, with which Priestley had nothing whatever to do, gave the signal to the loyal and pious mob, who, unchecked, and indeed to some extent encouraged, by those who were responsible for order, had the town at their mercy for three days. The chapels and houses of the leading Dissenters were wrecked, and Priestley and his family had to fly for their lives, leaving library, apparatus, papers, and all their possessions, a prey to the flames.

Priestley never returned to Birmingham. He bore the outrages and losses inflicted upon him with extreme patience and sweetness,[1] and betook himself to London. But even his scientific colleagues gave him a cold shoulder; and, though he was elected minister of a congregation at Hackney, he felt his position to be insecure, and finally determined on emigrating to the United States. He landed in America in 1794; lived quietly with his sons at Northumberland, in Pennsylvania, where his posterity still flourish; and, clear-headed and busy to the last, died February 6, 1804.

Such were the conditions under which Joseph Priestley did the work which lay before him, and then, as the Norse Sagas say, went out of the story. The work itself was of the most varied kind. No human interest was without its attraction for Priestley, and few men have ever had so many irons in the fire at once; but, though he may have burned his fingers a little, very few who have tried that operation have burned their fingers so little. He made admirable discoveries in science; his philosophical treatises are still well worth reading; his political works are full of insight and replete with the spirit of freedom; and, while all these sparks flew off from his anvil, the controversial hammer rained a hail of blows on orthodox priest and

[1] Even Mrs. Priestley, who might be forgiven for regarding the destroyers of her household gods with some asperity, contents herself, in writing to Mrs. Barbauld, with the sarcasm that the Birmingham people "will scarcely find so many respectable characters a second time to make a bonfire of."

bishop. While thus engaged, the kindly, cheerful doctor felt no more wrath or uncharitableness toward his opponents than a smith does toward his iron. But if the iron could only speak!—and the priests and bishops took the point of view of the iron.

No doubt what Priestley's friends repeatedly urged upon him—that he would have escaped the heavier trials of his life and done more for the advancement of knowledge, if he had confined himself to his scientific pursuits and let his fellow-men go their way—was true. But it seems to have been Priestley's feeling that he was a man and a citizen before he was a philosopher, and that the duties of the two former positions are at least as imperative as those of the latter. Moreover, there are men (and I think Priestley was one of them) to whom the satisfaction of throwing down a triumphant fallacy is as great as that which attends the discovery of a new truth; who feel better satisfied with the government of the world, when they have been helping Providence by knocking an imposture on the head; and who care even more for freedom of thought than for mere advance of knowledge. These men are the Carnots who organize victory for truth, and they are, at least, as important as the generals who visibly fight their battles in the field.

Priestley's reputation as a man of science rests upon his numerous and important contributions to the chemistry of gaseous bodies; and to form a just estimate of the value of his work—of the extent to which it advanced the knowledge of fact and the development of sound theoretical views—we must reflect what chemistry was in the first half of the eighteenth century.

The vast science which now passes under that name had no existence. Air, water, and fire, were still counted among the elemental bodies; and though Van Helmont, a century before, had distinguished different kinds of air as *gas ventosum* and *gas sylvestre*, and Boyle and Hales had experimentally defined the physical properties of air, and discriminated some of the various kinds of aëriform bodies, no one suspected the existence of the numerous totally distinct gaseous elements which are now known, or dreamed that the air we breathe and the water we drink are compounds of gaseous elements.

But, in 1754, a young Scotch physician, Dr. Black, made the first clearing in this tangled backwood of knowledge. And it gives one a wonderful impression of the juvenility of scientific chemistry to think that Lord Brougham, whom so many of us recollect, attended Black's lectures when he was a student in Edinburgh. Black's researches gave the world the novel and startling conception of a gas that was a permanently elastic fluid like air, but that differed from common air in being much heavier, very poisonous, and in having the properties of an acid, capable of neutralizing the strongest alkalies; and it took the world some time to become accustomed to the notion.

A dozen years later, one of the most sagacious and accurate investigators who has adorned this or any other country, Henry Cavendish, published a memoir in the "Philosophical Transactions," in which he deals not only with the "fixed air" (now called carbonic acid or carbonic anhydride) of Black, but with "inflammable air," or what we now term hydrogen.

By the rigorous application of weight and measure to all his processes, Cavendish implied the belief subsequently formulated by Lavoisier, that, in chemical processes, matter is neither created nor destroyed, and indicated the path along which all future explorers must travel. Nor did he himself halt until this path led him, in 1784, to the brilliant and fundamental discovery that water is composed of two gases united in fixed and constant proportions.

It is a trying ordeal for any man to be compared with Black and Cavendish, and Priestley cannot be said to stand on their level. Nevertheless, his achievements are not only great in themselves, but truly wonderful, if we consider the disadvantages under which he labored. Without the careful scientific training of Black, without the leisure and appliances secured by the wealth of Cavendish, he scaled the walls of science as so many Englishmen have done before and since his day; and, trusting to mother-wit to supply the place of training, and to ingenuity to create apparatus out of washing-tubs, he discovered more new gases than all his predecessors put together had done. He laid the foundation of gas analysis; he discovered the complementary actions of animal and vegetable life upon the constituents of the atmosphere; and, finally, he crowned his work, this day one hundred years ago, by the discovery of that "pure dephlogisticated air" to which the French chemists subsequently gave the name of oxygen. Its importance, as the constituent of the atmosphere which disappears in the processes of respiration and combustion, and is restored by green plants growing in sunshine, was proved somewhat later. For these brilliant discoveries the Royal Society elected Priestley a Fellow and gave him their medal, while the Academies of Paris and St. Petersburg conferred their membership upon him. Edinburgh had made him an honorary doctor of laws at an early period of his career; but, I need hardly add that a man of Priestley's opinions received no recognition from the universities of his own country.

That Priestley's contributions to the knowledge of chemical fact were of the greatest importance, and that they richly deserve all the praise that has been awarded to them, is unquestionable; but it must, at the same time, be admitted that he had no comprehension of the deeper significance of his work; and, so far from contributing any thing to the theory of the facts which he discovered, or assisting in their rational explanation, his influence to the end of his life was warmly exerted in favor of error. From first to last, he was a stiff adherent of the phlogiston doctrine which was prevalent when his studies commenced; and, by a curious irony of fate, the man, who by the discovery of what he called "dephlogisticated air" furnished the essential datum for the true theory of combustion, of respiration, and of the composition of water, to the end of his days fought against the inevitable corollaries from his own labors. His last scientific work, published in 1800, bears the title, "The Doctrine of Phlogiston established, and that of the Composition of Water refuted."

When Priestley commenced his studies, the current belief was, that atmospheric air, freed from accidental impurities, is a simple elementary substance, indestructible and unalterable, as water was supposed to be. When a combustible burned, or when an animal breathed in air, it was supposed that a substance, "phlogiston," the matter of heat and light, passed from the burning or breathing body into it, and destroyed its powers of supporting life and combustion. Thus, air contained in a vessel in which a lighted candle had gone out, or a living animal had breathed until it could breathe no longer, was called "phlogisticated." The same result was supposed to be brought about by the addition of what Priestley called "nitrous gas" to common air.

In the course of his researches, Priestley found that the quantity of common air which can thus become "phlogisticated" amounts to about one-fifth the volume of the whole quantity submitted to experiment. Hence it appeared that common air consists, to the extent of four-fifths of this volume, of air which is already "phlogisticated;" while the other fifth is free from phlogiston, or "dephlogisticated." On the other hand, Priestley found that air "phlogisticated" by combustion or respiration could be "dephlogisticated," or have the properties of pure common air restored to it, by the action of green plants in sunshine. The question, therefore, would naturally arise—as common air can be wholly phlogisticated by combustion, and converted into a substance which will no longer support combustion, is it possible to get air that shall be less phlogisticated than common air, and consequently, support combustion better than common air does?

Now, Priestley says that, in 1774, the possibility of obtaining air less phlogisticated than common air had not occurred to him.[1] But, in pursuing his experiments on the evolution of air from various bodies by means of heat, it happened that, on the 1st of August, 1774, he threw the heat of the sun, by means of a large burning-glass which he had recently obtained, upon a substance which was then called *mercurius calcinatus per se*, and which is commonly known as red precipitate:

"I presently found that, by means of this lens, air was expelled from it very readily. Having got about three or four times as much as the bulk of my materials, I admitted water to it, and found that it was not imbibed by it. But, what surprised me more than I can well express was, that a candle burned in this

[1] "Experiments and Observations on Different Kinds of Air," vol. ii., p. 31.

air with a remarkably vigorous flame, very much like that enlarged flame with which a candle burns in nitrous air, exposed to iron or lime of sulphur; but, as I had got nothing like this remarkable appearance from any kind of air besides this particular modification of nitrous air, and I knew no nitrous acid was used in the preparation of *mercurius calcinatus*, I was utterly at a loss how to account for it.

"In this case also, though I did not give sufficient attention to the circumstance at that time, the flame of the candle, besides being larger, burned with more splendor and heat than in that species of nitrous air; and a piece of red-hot wood sparkled in it, exactly like paper dipped in a solution of nitre, and it consumed very fast—an experiment which I had never thought of trying with nitrous air."[1]

Priestley obtained the same sort of air from red lead, but, as he says himself, he remained in ignorance of the properties of this new kind of air for seven months, or until March, 1775,[2] when he found that the new air behaved with "nitrous gas" in the same way as the dephlogisticated part of common air does; but that, instead of being diminished to four-fifths, it almost completely vanished, and therefore showed itself to be "between five and six times as good as the best common air I have ever met with."[3] As this new air thus appeared to be completely free from phlogiston, Priestley called it "dephlogisticated air."

What was the nature of this air? Priestley found that the same kind of air was to be obtained by moistening with the spirit of nitre (which he terms nitrous acid) any kind of earth that is free from phlogiston, and applying heat; and consequently he says, "There remained no doubt on my mind but that the atmospherical air, or the thing that we breathe, consists of the nitrous acid and earth, with so much phlogiston as is necessary to its elasticity, and likewise so much more as is required to bring it from its state of perfect purity to the mean condition in which we find it."[4]

Priestley's view, in fact, is that atmospheric air is a kind of saltpetre, in which the potash is replaced by some unknown earth. And in speculating on the manner in which saltpetre is formed, he enunciates the hypothesis, "that nitre is formed by a real *decomposition of the air itself*, the *bases* that are presented to it having, in such circumstances, a nearer affinity with the spirit of nitre than that kind of earth with which it is united in the atmosphere."[5]

It would have been hard for the most ingenious person to have wandered farther from the truth than Priestley does in this hypothesis of his—and though Lavoisier undoubtedly treated Priestley very ill, and pretended to have discovered dephlogisticated air, or oxygen, as he called it, independently, we can almost forgive him when we re-

[1] "Experiments and Observations on Different Kinds of Air," vol. ii., pp. 34, 35.

[2] Ibid., p. 40. [3] Ibid., p. 48. [4] Ibid., p. 55.

[5] Ibid., p. 60. The italics are Priestley's own.

flect how different were the ideas which the great French chemist attached to the body which Priestley discovered.

They are like two navigators, of whom the first sees a new country, but takes clouds for mountains and mirage for lowlands; while the second determines its length and breath, and lays down on a chart its exact place, so that it, thenceforth, serves as a guide to his successors, and becomes a secure outpost whence new explorations may be pushed.

Nevertheless, as Priestley himself somewhere remarks, the first object of physical science is to ascertain facts, and the service which he rendered to chemistry, by the definite establishment of a large number of new and fundamentally important facts, is such as to entitle him to a very high place among the fathers of chemical science.

It is difficult to say whether Priestley's philosophical, political, or theological views were most responsible for the bitter hatred which was borne to him by a large body of his countrymen,[1] and which found its expression in the malignant insinuations in which Burke, to his everlasting shame, indulged in the House of Commons.

Without containing much that will be new to the readers of Hobbes, Spinoza, Collins, Hume, and Hartley, and, indeed, while making no pretensions to originality, Priestley's "Disquisitions relating to Matter and Spirit," and his "Doctrine of Philosophical Necessity illustrated," are among the most powerful, clear, and unflinching expositions of materialism and necessarianism which exist in the English language, and are still well worth reading.

Priestley denied the freedom of the will in the sense of its self-determination; he denied the existence of a soul distinct from the body; and, as a natural consequence, he denied the natural immortality of man.

In relation to these matters, English opinion, a century ago, was very much what it is now.

A man may be a necessarian without incurring graver reproach than that implied in being called a gloomy fanatic, necessarianism, though very shocking, having a note of Calvinistic orthodoxy: but, if a man is a materialist; or, if good authorities say he is and must be so, in spite of his assertion to the contrary; or, if he acknowledge himself unable to see good reasons for believing in the natural immortality

[1] "In all the newspapers and most of the periodical publications I was represented as an unbeliever in Revelation, and no better than an atheist."—*Autobiography*, Hutt, vol. i., p. 124. "On the walls of houses, etc., and especially where I usually went, were to be seen, in large characters, 'MADAN FOREVER; DAMN PRIESTLEY; NO PRESBYTERIANISM; DAMN THE PRESBYTERIANS,' etc., etc.; and, at one time, I was followed by a number of boys, who left their play, repeating what they had seen on the walls, and shouting out, '*Damn Priestley; damn him, damn him, forever, forever*,' *etc., etc.* This was no doubt a lesson which they had been taught by their parents, and what they, I fear, had learned from their superiors."—*Appeal to the Public on the Subject of the Riots at Birmingham.*

of man, respectable folks look upon him as an unsafe neighbor of a cash-box, as an actual or potential sensualist, the more virtuous in outward seeming, the more certainly loaded with secret "grave personal sins."

Nevertheless, it is as certain as any thing can be, that Joseph Priestley was no gloomy fanatic, but as cheerful and kindly a soul as ever breathed, the idol of children; a man who was hated only by those who did not know him, and who charmed away the bitterest prejudices in personal intercourse; a man who never lost a friend, and the best testimony to whose worth is the generous and tender warmth with which his many friends vied with one another in rendering him substantial help, in all the crises of his career.

The unspotted purity of Priestley's life, the strictness of his performance of every duty, his transparent sincerity, the unostentatious and deep-seated piety which breathes through all his correspondence, are in themselves a sufficient refutation of the hypothesis, invented by bigots to cover uncharitableness, that such opinions as his must arise from moral defects. And his statue will do as good service as the brazen image that was set upon a pole before the Israelites, if those who have been bitten by the fiery serpents of sectarian hatred, which still haunt this wilderness of a world, are made whole by looking upon the image of a heretic, who was yet a saint.

Though Priestley did not believe in the natural immortality of man, he held with an almost naïve realism, that man would be raised from the dead by a direct exertion of the power of God, and thenceforward be immortal. And it may be as well for those who may be shocked by this doctrine to know that views, substantially identical with Priestley's, have been advocated, since his time, by two prelates of the Anglican Church: by Dr. Whately, Archbishop of Dublin, in his well-known "Essays;"[1] and by Dr. Courtenay, Bishop of Kingston in Jamaica, the first edition of whose remarkable book, "On the Future States," dedicated to Archbishop Whately, was published in 1843, and the second in 1857. According to Bishop Courtenay—

> "The death of the body will cause a cessation of all the activity of the mind by way of natural consequence; to continue forever UNLESS the Creator should interfere."

And again:

> "The natural end of human existence is the 'first death,' the dreamless slumber of the grave, wherein man lies spellbound, soul and body, under the dominion of sin and death—that whatever modes of conscious existence, whatever future states of 'life' or of 'torment' beyond Hades are reserved for man, are results of our blessed Lord's victory over sin and death; that the resurrection of the dead must be preliminary to their entrance into either of the future states, and that the nature and even existence of these states, and even the mere

[1] First Series. "On Some of the Peculiarities of the Christian Religion." Essay I. Revelation of a Future State.

fact that there is a futurity of consciouness, can be known *only* through God's revelation of himself in the Person and the Gospel of his Son," p. 389.

And now hear Priestley:

"Man, according to this system" (of materialism), "is no more than we now see of him. His being commences at the time of his conception, or perhaps at an earlier period. The corporeal and mental faculties, in being in the same substance, grow, ripen, and decay together; and whenever the system is dissolved it continues in a state of dissolution till it shall please that Almighty Being who called it into existence to restore it to life again."—*Matter and Spirit*, p. 49.

And again:

"The doctrine of the Scripture is, that God made man of the dust of the ground, and, by simply animating this organized matter, made man that living percipient and intelligent being that he is. According to Revelation, *death* is a state of rest and insensibility, and our only though sure hope of a future life is founded on the doctrine of the resurrection of the whole man at some distant period; this assurance being sufficiently confirmed to us, both by the evident tokens of a Divine commission attending the persons who delivered the doctrine, and especially by the actual resurrection of Jesus Christ, which is more authentically attested than any other fact in history."—*Ibid.*, p. 247.

We all know that "a saint in crape is twice a saint in lawn;" but it is not yet admitted that the views which are consistent with such saintliness in lawn become diabolical when held by a mere Dissenter.[1]

I am not here either to defend or to attack Priestley's philosophical views, and I cannot say that I am personally disposed to attach much value to episcopal authority in philosophical questions; but it seems right to call attention to the fact that those of Priestley's opinions which have brought most odium upon him have been openly promulgated, without challenge, by persons occupying the highest positions in the state Church.

I must confess that what interests me most about Priestley's materialism is, the evidence that he saw dimly the seed of destruction which such materialism carries within its own bosom. In the course of his reading for his "History of Discoveries relating to Vision, Light, and Colors," he had come upon the speculations of Boscovich and Michell, and had been led to admit the sufficiently obvious truth that our knowledge of matter is a knowledge of its properties; and that of its substance—if it have a substance—we know nothing. And

[1] Not only is Priestley at one with Bishop Courtenay in this matter, but with Hartley and Bonnet, both of them stout champions of Christianity. Moreover, Archbishop Whately's essay is little better than an expansion of the first paragraph of Hume's famous essay on the Immortality of the Soul: "By the mere light of reason it seems difficult to prove the immortality of the soul; the arguments for it are commonly derived either from metaphysical topics, or moral, or physical. But it is in reality the Gospel, and the Gospel alone, that has brought *life and immortality to light*." It is impossible to imagine that a man of Whately's tastes and acquirements had not read Hume or Hartley, though he refers to neither.

this led to the further admission that, so far as we can know, there may be no difference between the substance of matter and the substance of spirit ("Disquisitions," p. 16). A step further would have shown Priestley that his materialism was, in substance, very little different from the idealism of his contemporary, the Bishop of Cloyne.

As Priestley's philosophy is mainly a clear statement of the views of the deeper thinkers of his day, so are his political conceptions based upon those of Locke. Locke's aphorism, that "the end of government is the good of mankind," is thus expanded by Priestley:

> "It must necessarily be understood, therefore, whether it be expressed or not, that all people live in society for their mutual advantage; so that the good and happiness of the members, that is, of the majority of the members, of any state, is the great standard by which every thing relating to that state must finally be determined."[1]

The little sentence here interpolated, "that is, of the majority of the members of any state," appears to be that passage which suggested to Bentham, according to his own acknowledgment, the famous "greatest happiness" formula, which, by substituting "happiness" for "good," has converted a noble into an ignoble principle. But I do not call to mind that there is any utterance in Locke quite so outspoken as the following passage in the "Essay on the First Principles of Government." After laying down, as "a fundamental maxim in all governments," the proposition that "kings, senators, and nobles," are "the servants of the public," Priestley goes on to say:

> "But in the largest states, if the abuses of the government should at any time be great and manifest; if the servants of the people, forgetting their masters and their masters' interest, should pursue a separate one of their own; if, instead of considering that they are made for the people, they should consider the people as made for them; if the oppressions and violation of right should be great, flagrant, and universally resented; if the tyrannical governors should have no friends but a few sycophants, who had long preyed upon the vitals of their fellow-citizens, and who might be expected to desert a government whenever their interests should be detached from it; if, in consequence of these circumstances, it should become manifest that the risk which would be run in attempting a revolution would be trifling, and the evils which might be apprehended from it were far less than those which were actually suffered, and which were daily increasing; in the name of God, I ask, what principles are those which ought to restrain an injured and insulted people from asserting their natural rights, and from changing or even punishing their governors—that is, their servants—who had abused their trust, or from altering the whole form of their government, if it appeared to be of a structure so liable to abuse?"

As a Dissenter, subject to the operation of the Corporation and Test Acts, and as a Unitarian, excluded from the benefit of the Toleration Act, it is not surprising to find that Priestley had very definite

[1] "Essay on the First Principles of Government," second edition, 1771, p. 13.

opinions about ecclesiastical establishments; the only wonder is that these opinions were so moderate as the following passages show them to have been:

"Ecclesiastical authority may have been necessary in the infant state of society, and, for the same reason, it may perhaps continue to be, in some degree, necessary as long as society is imperfect; and therefore may not be entirely abolished till civil governments have arrived at a much greater degree of perfection. If, therefore, I were asked whether I should approve of the immediate dissolution of all the ecclesiastical establishments in Europe, I should answer, No. . . . Let experiment be first made of *alterations*, or, which is the same thing, of *better establishments* than the present. Let them be reformed in many essential articles, and then not thrown aside entirely till it be found by experience that no good can be made of them."

Priestley goes on to suggest four such reforms of a capital nature:

"1. Let the Articles of Faith to be subscribed by candidates for the ministry be greatly reduced. In the formulary of the Church of England, might not thirty-eight out of the thirty-nine be very well spared? It is a reproach to any Christian establishment if every man cannot claim the benefit of it who can say that he believes in the religion of Jesus Christ as it is set forth in the New Testament. You say the terms are so general that even deists would quibble and insinuate themselves. I answer that all the articles which are subscribed at present by no means exclude deists who will prevaricate; and upon this scheme you would at least exclude fewer honest men." [1]

The second reform suggested is the equalization, in proportion to work done, of the stipends of the clergy; the third, the exclusion of the bishops from Parliament; and the fourth, complete toleration, so that every man may enjoy the rights of a citizen, and be qualified to serve his country, whether he belong to the Established Church or not.

Opinions such as those I have quoted, respecting the duties and the responsibilities of governors, are the commonplaces of modern Liberalism; and Priestley's views on ecclesiastical establishments would, I fear, meet with but a cool reception, as altogether too conservative, from a large proportion of the lineal descendants of the people who taught their children to cry "Damn Priestley," and, with that love for the practical application of science which is the source of the greatness of Birmingham, tried to set fire to the doctor's house with sparks from his own electrical machine, thereby giving the man, they called an incendiary and raiser of sedition against Church and king, an appropriately experimental illustration of the nature of arson and riot.

If I have succeeded in putting before you the main features of Priestley's work, its value will become apparent when we compare the condition of the English nation, as we knew it, with its present state.

The fact, that France has been for eighty-five years trying, without

[1] "Utility of Establishments," in "Essay on First Principles of Government," p. 198, 1771.

much success, to right herself after the great storm of the Revolution, is not unfrequently cited among us as an indication of some inherent incapacity for self-government among the French people. I think, however, that Englishmen who argue thus forget that, from the meeting of the Long Parliament in 1640, to the last Stuart rebellion in 1745, is a hundred and five years, and that, in the middle of the last century, we had but just freed ourselves from our Bourbons and all that they represented. The corruption of our state was as bad as that of the Second Empire. Bribery was the instrument of government, and peculation its reward. Four-fifths of the seats in the House of Commons were more or less openly dealt with as property. A minister had to consider the state of the vote market, and the sovereign secured a sufficiency of "king's friends" by payments allotted with retail, rather than royal, sagacity.

Barefaced and brutal immorality and intemperance pervaded the land, from the highest to the lowest classes of society. The Established Church was torpid, so far as it was not a scandal; but those who dissented from it came within the meshes of the Act of Uniformity, the Test Act, and the Corporation Act. By law, such a man as Priestley, being a Unitarian, could neither teach nor preach, and was liable to ruinous fines and long imprisonment.[1] In those days, the guns that were pointed by the Church against the Dissenters were shotted. The law was a cesspool of iniquity and cruelty. Adam Smith was a new prophet whom few regarded, and commerce was hampered by idiotic impediments, and ruined by still more absurd help, on the part of government.

Birmingham, though already the centre of a considerable industry, was a mere village as compared with its present extent. People who traveled went about armed, by reason of the abundance of highwaymen and the paucity and inefficiency of the police. Stage-coaches had not reached Birmingham, and it took three days to get to London. Even canals were a recent and much-opposed invention.

Newton had laid the foundation of a mechanical conception of the physical universe; Hartley, putting a modern face upon ancient materialism, had extended that mechanical conception to psychology; Linnæus and Haller were beginning to introduce method and order into the chaotic accumulation of biological facts. But those parts of physical science which deal with heat, electricity, and magnetism, and, above all, chemistry, in the modern sense, can hardly be said to have had an existence. No one knew that two of the old elemental bodies, air and water, are compounds, and that a third, fire, is not a substance but a motion. The great industries that have grown out of the applications of modern scientific discoveries had no existence, and the man, who should have foretold their coming into being in the days of his son, would have been regarded as a mad enthusiast.

[1] In 1732 Doddridge was cited for teaching without the bishop's leave, at Northampton.

In common with many other excellent persons, Priestley believed that man is capable of reaching, and will eventually attain, perfection. If the temperature of space presented no obstacle, I should be glad to entertain the same idea; but, judging from the past progress of our species, I am afraid that the globe will have cooled down so far before the advent of this natural millennium, that we shall be, at best, perfected Esquimaux. For all practical purposes, however, it is enough that man may visibly improve his condition in the course of a century or so. And, if the picture of the state of things in Priestley's time, which I have just drawn, have any pretense to accuracy, I think it must be admitted that there has been a considerable change for the better.

I need not advert to the well-worn topic of material advancement, in a place in which the very stones testify to that progress—in the town of Watt and of Boulton. I will only remark, in passing, that material advancement has its share in moral and intellectual progress. Becky Sharp's acute remark, that it is not difficult to be virtuous on ten thousand a year, has its application to nations; and it is futile to expect a hungry and squalid population to be any thing but violent and gross. But as regards other than material welfare, although perfection is not yet in sight—even from the mast-head—it is surely true that things are much better than they were.

Take the upper and middle classes as a whole, and it may be said that open immorality and gross intemperance have vanished. Four and six bottle men are as extinct as the dodo. Women do not gamble, and talk modeled upon Dean Swift's "Art of Polite Conversation" would be tolerated in no decent kitchen.

Members of the legislature are not to be bought, and constituents are awakening to the fact that votes must not be sold—even for such trifles as rabbits and tea and cake. Political power has passed into the hands of the masses of the people. Those whom Priestley calls their servants have recognized their position, and have requested the master to be so good as to go to school and fit himself for the administration of his property. No civil disability attaches to any one on theological grounds, and the highest offices of the state are open to papist, Jew, or secularist.

Whatever men's opinions as to the policy of Establishment, no one can hesitate to admit that the clergy of the Church are men of pure life and conversation, zealous in the discharge of their duties, and, at present, apparently, more bent on prosecuting one another than on meddling with Dissenters. Theology itself has broadened so much, that Anglican divines put forward doctrines more liberal than those of Priestley; and, in our state-supported churches, one listener may hear a sermon to which Bossuet might have given his approbation, while another may hear a discourse in which Socrates would find nothing new.

But, great as these changes may be, they sink into insignificance beside the progress of physical science, whether we consider the improvement of methods of investigation, or the increase in bulk of solid knowledge. Consider that the labors of Laplace, of Young, of Davy, and of Faraday; of Cuvier, of Lamarck, and of Robert Brown; of Von Baer, and of Schwann; of Smith and of Hutton, have all been carried on since Priestley discovered oxygen; and consider that they are now things of the past, concealed by the industry of those who have built upon them, as the first founders of a coral-reef are hidden beneath the life's work of their successors; consider that the methods of physical science are slowly spreading into all investigations, and that proofs, as valid as those required by her canons of investigation, are being demanded of all doctrines which ask for men's assent—and you will have a faint image of the astounding difference in this respect between the nineteenth century and the eighteenth.

If we ask what is the deeper meaning of all these vast changes, I think there can be but one reply. They mean that Reason has asserted and exercised her primacy over all provinces of human activity: that ecclesiastical authority has been relegated to its proper place; that the good of the governed has been finally recognized as the end of government, and the complete responsibility of governors to the people as its means; and that the dependence of natural phenomena in general, on the laws of action of what we call matter, has become an axiom.

But it was to bring these things about, and to enforce the recognition of these truths, that Joseph Priestley labored. If the nineteenth century is other and better than the eighteenth, it is to him and to such men as he that we owe the change. If the twentieth century is to be better than the nineteenth, it will be because there are among us men who walk in Priestley's footsteps.

Such men are not those whom their own generation delights to honor; such men, in fact, rarely trouble themselves about honor, but ask, in another spirit than Falstaff's, "What is honor? Who hath it? He that died o' Wednesday." But whether Priestley's lot be theirs, and a future generation, in justice and in gratitude, set up their statues; or whether their names and fame are blotted out from remembrance, their work will live as long as time endures. To all eternity, the sum of truth and right will have been increased by their means; to all eternity, falsehood and injustice will be the weaker because they have lived.—*From advance sheets of Macmillan's Magazine.*

SKETCH OF PROFESSOR HAECKEL.

ERNST HEINRICH HAECKEL, Professor of Natural History in the University of Jena, and one of the most eminent of German biologists, was born at Potsdam, in Prussia, on the 16th of February, 1834, and is consequently now but forty years of age. In his childhood he was very fond of botany. He studied medicine and the natural sciences at Berlin and Würzburg, and graduated as doctor of medicine in Berlin in 1857. In Würzburg he studied anatomy and histology under Kölliker and Leydig, and in Berlin under Johannes Müller. He became the assistant of the eminent pathologist Virchow, and commenced medical practice in Berlin in 1858. He had made scientific excursions to the Mediterranean in 1854 and 1856 with Kölliker and Müller; and in 1859–'60 a fifteen months' residence in Italy, which he employed in zoological researches, became the turning-point in his career, and he withdrew from the practice of medicine, and became a professed zoologist. He went to Jena in 1861, and was made professor extraordinary in the university in 1862. In 1865 the university created a regular chair of zoology specially for him, and he began the formation there of a valuable museum. From that time his lectures, together with those of Gegenbaur on comparative anatomy, have given great reputation to the Jena school. Prof. Haeckel is said to have declined very advantageous appointments to other universities mainly because he would not be separated from his friend Gegenbaur. Prof. Haeckel early accepted the views of Mr. Darwin, and has become their leading expositor in Germany. He has, besides, greatly extended and strengthened the theory of organic development by his own researches. His biographer in the AMERICAN CYCLOPÆDIA states that in 1863 "Darwinism" was generally looked upon with great disfavor in German scientific circles; and when, on September 19th of that year, Prof. Haeckel appeared before the convention of German physicians and naturalists held in Stettin, as the enthusiastic advocate of development doctrines, he stood almost alone, and thenceforth he determined to devote his life to their extension, establishment, and promulgation.

In 1866 he completed a work on the general morphology of organisms, in two volumes, which ranks as one of the landmarks of the science. In that work he propounded, as a fundamental biological law, "that the individual development of every organism, or the series of forms through which it passes from germ to complete form, repeats approximately the development of its race, or the series of forms through which its ancestors have passed. Moreover, all organic beings, hitherto, had been classified into the two kingdoms, animal and vegetable; but a number of creatures were found to present in external form, in internal structure, and in all vital phenomena, so remarkable a mixture or combination of distinguishing animal and vegetable characteristics, that it was impossible, except arbitrarily, to assign them to either realm: he assigned these doubtful beings to a kingdom by themselves, below and yet between the two other organic kingdoms, and this he called *protistic*. Again and again in existing forms he traced development from preëxisting ones. Many biologists, among them Prof. Huxley, have pronounced this the most important work of the kind ever published."

In the winter of 1867–'68 he delivered a series of popular lectures, on the evolution doctrine in general, which were afterward amplified and published under the title of "The Natural History of Creation." Many editions of it have been called for, and it has been translated into several languages. Darwin says of it, in the introduction to the "Descent of Man:" "If this work had appeared before my essay had been written, I should probably never have completed it. Almost all the conclusions at which I have arrived, I find confirmed by this naturalist, whose knowledge on many points is much fuller than mine." This work will soon appear in English.

Prof. Haeckel's most important original contribution to the doctrine of evolution has been made by the study of the sponges. Considering that Darwin's mode of investigation was only synthetical, that is, "to prove the truth of the transmutation theory by arguments from philosophy and biology, from comparative anatomy and paleontology, by considerations of the mutual affinities of organic beings, of their embryological relations, their geographical distribution, geological succession, etc." Prof. Haeckel aimed to establish the theory by direct analytical proof. For this purpose "he has selected the group of calcareous sponges, and has shown by thousands of examinations the gradual transitions from the most simple to the most perfect sponge form." Prof. Haeckel's last considerable work is "The History of the Evolution of Man," just ready for issue in Germany, and a very large edition of which has been subscribed for. A translation of this work also will soon appear in English.

We are indebted for the leading facts of this sketch to the excellent notice of Haeckel in Volume VIII. of the American Cyclopædia, where the reader will find a much fuller statement of his numerous contributions to biological science.

EDITOR'S TABLE.

MATTER AND LIFE.

THE narrow limits of Prof. Tyndall's address, the greatness of the questions it raised, and the diversity of views to which it has given rise, seem to have led to much erroneous interpretation of the document. Many newspapers have charged that the speech is an unprecedented and unwarranted aggression upon ground to which science has no rightful claim, and even the *Scientific American* describes the position taken by Prof. Tyndall as a "sudden invasion of the neutral territory lying between scientific and religious thought." The passage that has been most constantly quoted and relied upon, to show that Prof. Tyndall has quit his own field and intruded into that which belongs to religion, is where he speaks of "prolonging his vision across the boundary of the experimental evidence." But it is easy to show that this passage will bear no such construction; that is, what Prof. Tyndall proposes to do is, exactly what all men of science have been about these hundred years. Let us see what he means, which may be the best done by detaching from the address the full statement in which the passage occurs. Prof. Tyndall says: "Two courses, and two only, are possible. Either let us open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of matter. If we look at matter as pictured by Democritus, and as defined for generations in our text-books, the absolute impossibility of any form of life coming out of it would be sufficient to render any other hypothesis preferable; but the definitions of matter given in our text-books were intended to cover its purely physical and mechanical properties. And, taught as we have been to regard these definitions as complete, we naturally and rightly reject the monstrous notion that out of *such* matter any form of life could possibly arise. But are the definitions complete? Every thing depends on the answer to be given to this question. Trace the line of life backward, and see it approaching more and more to what we call the purely physical condition. We reach at length those organisms which I have compared to drops of oil suspended in a mixture of alcohol-and-water. We reach the *protogenes* of Haeckel, in which we have 'a type distinguishable from a fragment of albumen only by its finely-granular character.' Can we pause here? We break a magnet, and find two poles in each of its fragments. We continue the process of breaking, but, however small the parts, each carries with it, though enfeebled, the polarity of the whole. And, when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that 'Nature is seen to do all things spontaneously of herself, without the meddling of the gods?' or with Bruno, when he declares that Matter is not 'that mere empty *capacity* which philosophers have pictured her to be, but the universal mother who brings forth all things as the fruit of her own womb?' The questions here raised are inevitable. They are approaching us with accelerated speed, and it is not a matter of indifference whether they are introduced with reverence or irreverence. Abandoning all disguise, the confession that I feel bound to make before you is, that I prolong the vision backward across the boundary of the experimental evidence, and discern, in that matter which we in our ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life."

Now, what does Prof. Tyndall here mean by prolonging the intellectual vision across the boundary of the experimental evidence? He has defined exactly what he means, and given an example of it in the case of the magnet, whose broken particles exhibit polarity, "and, when we can break no longer, *we prolong the intellectual vision to the polar molecules*." That is, molecules and atoms are not objects of sense, and therefore of experiment, but can be cognized only by the intellect. Prof. Tyndall must leave experiment before he can reach them, as they lie far beyond and below all possibility of ever being reached by that method; they are objects of inference, hypothetical creations, and belong to the world of thought. But can it be pretended that they do not also belong to science? All modern physics and chemistry have, for their foundation, conceptions of the molecular constitution of matter. Is the establishment of the great division of molecular physics—is the elaboration of that wonderful system of molecular constructions—the "new chemistry"—an illegitimate and unscientific mental procedure? Was the pious Quaker Dalton guilty of breaking the bounds of science and trespassing upon the territory of religion, when he passed the limits of experimental evidence and reconstructed the atomic theory in accordance with the newly-ascertained laws of chemical action? This must have been so if the charge now made against Prof. Tyndall is valid. And if scientific men are not to be allowed to cross the boundaries of experimental evidence, and reason upon the sub-sensible conditions, powers, and constitution of matter, then there is simply an end to science.

But this is not all. Prof. Tyndall claims that there is a great deal more, in this mysterious and unfathomable something which we call matter, than has been hitherto allowed; he sees in it "the promise and potency of every form and quality of life." Much horror has been expressed at this statement, but the expressions seem to us quite gratuitous. We should like to know what form or quality of life there is, that is not manifested in matter, and is not, therefore, to be ranked among its potentialities. All living things are material things; all organized creatures are constituted of material elements; and, throughout the scale of life, vital, chemical, and physical powers are correlated in inextricable complication, and displayed through a substratum of ponderable constituents. Of the sixty-odd chemical elements, four are chiefly concerned in the maintenance of life; they constitute the mass of all living things, and have long been classified as *organogens*—generators of organization. The mutations of these elements involve the cycles of life. Earth, sea, and air, are filled with myriads of vital forms, and through countless millions of years the earth has swarmed with them, while whole rocky systems are made up of their material remnants. When the microscope was invented, and the frontiers of old observation were crossed, a new world of life was discovered; and, as the powers of the instrument were improved, minuter creatures were disclosed, grade after grade, until organisms were found not the millionth of an inch in diameter. Those who deny spontaneous generation, or that living beings are directly engendered out of matter, are only able to do so by prolonging their vision beyond the sensible evidence, and assuming that Nature is pervaded by infinitely tenuous, inscrutable, though still material life-germs. But, whatever the processes by which Nature breaks into this multitudinous life, it is undoubtedly done through an inflexible system of law. There is no irregularity, caprice, or miracle, about it; it is a phase of the established order of things, and vital effects can no more be dissociated from the properties and powers of matter than can chemical or physical effects. How far it is possible to unravel the mysteries of life is not the question; how erroneous may be existing theories upon the subject is not now the question. Hypothetical views in relation to it may be false, and the problem itself may be insoluble; but, whether this be so or not, or how far the solution is possible, it is for science alone to determine. Certainly it is not for those who have ever disdained the study of matter to tell us what it can do and what it cannot do, and how far science is to be permitted to go in exploring it. Those who revile matter, and invent insulting epithets to be applied to those who study it, and who consign to execration one of its devoted students for expressing a more exalted sense of its wonderful offices, are evidently not well prepared to instruct us upon the subject.

The theologians are now freely using the harmonies and adaptations of Nature as proofs of wisdom and design on the part of the Creator. But to whom are they indebted for a knowledge of this evidence? To the scientists who have disclosed this order, harmony, and adaptation, by the study of matter. The domain which theology of old allotted to the devil, science has rescued to the service of religion by the revelation of its marvelous powers and capacities; why, then, condemn the scientist if, pushing on his investigation yet further, he claims to discern yet higher potencies and possibilities in this divine material of which the universe is constituted?

MINERAL-COLLECTING.

In accordance with the wishes of many mineral-collectors, who regard the practice in vogue among mineralogists, of exchanging the minerals of their own for those of other localities by a system of barter, as in many respects unsatisfactory and unproductive, Prof. Leeds, of the Stevens Institute, has proposed in a printed circular, a copy of which has been placed in our hands, to discontinue this time-honored custom, and to inaugurate a system of purchase. In accordance with a plan stated in an article entitled "State Geological Surveys," in The Popular Science Monthly of June, 1873, he has collected the minerals occurring within the province in which the institution with which he is connected is located. Quarrymen have been kept constantly employed in blasting for a number of months past, and several thousand specimens have been obtained, all of which have been paid for at the prices usual for this description of labor. It is evident that finely-crystallized minerals collected in this way can be exchanged in the ordinary fashion of barter, only at pecuniary loss in most cases, and nearly always with some measure of dissatisfaction to one or the other party in the transaction. Those who have been most generous and fair in their exchanges have been those who have suffered most. Instead of bartering, the circular announces that prices sufficient to cover the expenses of collecting have been placed upon the specimens, and they are to be sold. The money received from their sale will be devoted to the purchase of specimens for the institute collection, and minerals sent as exchanges must be priced by the senders, and paid for on the same principles as regulate the purchase of chemicals, apparatus, or any other commercial article. For explanatory circulars, catalogues, etc., address Prof. A. R. Leeds, Stevens Institute, Hoboken, New Jersey.

PROFESSOR CAIRNES ON WOMAN SUFFRAGE.

Goldwin Smith's article upon this subject, which was reproduced in the August Monthly, has been replied to in *Macmillan's Magazine*, where it first appeared, by J. E. Cairnes, the distinguished Professor of Political Economy in University College, London. The article, though a spirited polemic, contributes but little to the radical question, and in our opinion by no means satisfactorily answers Prof. Smith's objections; while we are far from thinking that Mr. Smith himself went to the root of the subject in giving the reasons of his positions. He is of opinion that the extension of political suffrage to the female sex would prove destructive to free institutions, which Prof. Cairnes thinks a groundless and absurd apprehension. But this grave question we believe cannot be determined without going deeper into the subject than either of these writers has done. If the natures of women are the same as those of men, then their enfranchisement might be expected to produce but little change in the course of political affairs; but if women are profoundly different in mental and emotional constitution from men, then the entrance of this new element into the political sphere, by which the voters would be more than doubled, would certainly alter the composition of political forces and the direction of political movement. It is worthy of remark, in passing, that the leading advocates of woman suffrage, while affirming the equality of the sexes and the essential identity of the masculine and feminine mind, nevertheless urge the policy of female enfranchisement on the ground of the numerous new results that would follow, and which would be widely different from those now realized.

There are but two ways of ascertaining what these consequences would be: first, by making the experiment on a national scale and for a lengthened period, because, in the absence of revolution, changes in social and civil types proceed slowly. The second method of ascertaining the consequences of female enfranchisement, and the only practicable method, is, to infer them from the nature of political institutions on one hand, and from the female character on the other. We are here confronted with three scientific problems. We have to consider the natural constitution of society, and find out what are the laws of social change, and the conditions under which social development has thus far taken place. This subject is deeper than politics, which deals with conventional arrangements, and what we may call the superficies of society; and goes down to those relations that underlie all political forms, and pertain to the essential unfolding of humanity. We have also to consider woman in the light of biological science—that is, the physiological nature, modifications, and limitations of her sex; and we have again to study her mental and emotional traits as determined by her biological constitution and maternal experience. These we hold to be the fundamental problems of the woman question, which must be elucidated before there can be any sufficient data for intelligent action; and, until they are more fully elucidated than at present, all action will be but blind and hap-hazard experiments, and far more likely to produce evil than good.

We publish that portion of Prof. Cairnes's article—the most important part—in which he deals with the relation of woman suffrage to the family; but the argument is unsatisfactory. The "element of weakness in the family, as things now stand," he says, is the "want of sufficient subjects of common interest between man and woman;" certainly a most astounding averment. Man and woman in the family mean husband and wife, father and mother, growing children, home-education, the formation of character and the outer social relations that spring from the family circle. The home, by its very constitution, is at the same time the centre of the tenderest and strongest emotions, and the place where all the faculties of the intellect may be brought into the fullest exercise. From the most trivial questions of the ordering of the household, up to the ever-impending contingencies of life and death, there is occasion for sleepless solicitude, unremitting thought, and extensive knowledge. There is room for the play of the æsthetic faculties and a cultivated taste; there is need of light from various sciences; there is demand for a cautious logic; there is required a direct knowledge of things, as well as of book information, and also a training in practical household concerns. All these are constant and pressing subjects in which both father and mother should be interested and instructed, upon which the very destiny of the family depends. And yet Prof. Cairnes tells us that the present element of weakness in the family is the *want of sufficient subjects of common interest!* He is mistaken; there are subjects enough of mutual concern, but the element of weakness is that they are neglected. He would elevate and strengthen the family by having the women go into politics; we are quite clear that this is not the way the family is to be elevated and improved. Prof. Cairnes's remedy is no remedy at all, and would rather be a fatal hindrance. The general effect would be to preoccupy the female mind with public instead of private and domestic interests; and to divert attention from those home questions which are in fact a thousand times more important to the community than the issues of partisan strife.

THE RIGHTS OF ORIGINALITY.

To fair-minded readers, apology will be unnecessary for the very considerable space that we devote this month to the relation of Herbert Spencer to the doctrine of Evolution: the misconceptions that have prevailed, regarding Mr. Spencer's relation to this great doctrine, make such a statement as this indispensable in the interest of justice. Much of the misunderstanding and erroneous representation is undoubtedly due to the general ignorance of a subject which has recently attained unexpected prominence, and has to be discussed by many who are not well informed about it. For example, in an able and liberal article on Prof. Tyndall's late address, in *Harper's Weekly*, Mr. Darwin is declared to be "the most famous expounder of Evolution." This is so far from being true, that Mr. Darwin has never even attempted any such thing. He has devoted his life to special and important researches, which bear upon the principle of organic development; but his writings, though rich in biological contributions to the question, do not contain any thing like a full or comprehensive exposition of the subject. Whole tracts of the inquiry they do not touch; the general evidence of the truth of Evolution they do not give; nor do they subject the problem to that rigorous analysis into its ultimate elements and factors which scientific investigation requires. Mr. Darwin has shown with great learning how the principle of natural selection gives rise to diversities of organic species; but natural selection is no more Evolution than a fusee is a watch, or a throttle-valve a steam-engine; and *Harper's Weekly* might as well send its readers to a treatise on Arches to get a knowledge of Architecture as to Mr. Darwin's writings to get a knowledge of Evolution. Perhaps no living man is better acquainted with what Mr. Darwin has done than Prof. Huxley; but, in a lecture before the Royal Institution of Great Britain, he said: "The only complete and systematic statement of the doctrine" (Evolution) "with which I am acquainted, is that contained in Mr. Herbert Spencer's 'System of Philosophy,' a work which should be carefully studied by all who desire to know whither scientific thought is tending."

It is to correct errors like this, which are wide-spread and do serious injustice to Mr. Spencer, that we have thought it necessary to go carefully into the subject, and furnish the evidence on which Mr. Spencer's claims to originality are founded.

PHOTOGRAPHY AND THE CHEMICAL CENTENNIAL.

It was fitting that, at the Priestley centennial of the discovery of oxygen gas, two of the grandest achievements of modern science should have been called into requisition, to make the event known far beyond the circle of those who participated in the occasion. The telegraph reported the doings to all the contemporary world who cared about them, and the photograph preserved many of its interesting features pictorially, for the benefit of future generations. It was the general wish of those present that photographs should be made of the house which Dr. Priestley built and in which he died, and of the collections of his scientific apparatus. We are happy to see that this desire has been complied with, and a series of pictures taken, which represent the objects of chief interest in the celebration. No. I. is a group of chemists, representing 72 figures of the scientific men who attended the centennial meeting; No. II. Dr. Priestley's residence, showing the house and laboratory; No. III. Copy of a rare old engraving, showing the fury of the mob which destroyed Priestley's house in Birmingham; No. IV. Priestley's chemical apparatus; No. V. His electrical apparatus; No. VI. His physical apparatus. These three groups are from the Loan Exhibition. No. VII. Interior view of the Loan Exhibition; No. VIII. Headstone of Priestley's grave. These photographs are mounted on eight by ten Bristol board, price 50 cents each, or $3.50 for the set of eight. They may be ordered from Louis H. Laudy, School of Mines, Columbia College, New York.

LITERARY NOTICES.

The Building of a Brain. By Edward H. Clarke, M. D. 153 pages. Price, $1.25. Boston: J. R. Osgood & Co.

Dr. Clarke did the country a service last year, by publishing his little volume entitled "Sex in Education," in which he called attention to some physiological points in the school-experience of girls, in such a way as to provoke half a score of replies, and to bring the subject very effectually before the public. He took ground against co-education, or the subjection of girls to the same conditions of study as boys, and showed how that system works serious and extensive injuries to the female constitution. The little volume now issued, while it is not a formal reply to his critics, pursues the subject of the physiological basis of education. Instead of dealing with mind as an abstraction, he takes up the brain in which it is embodied, and shows how mental development is, at bottom, really a process of "brain-building." Metaphysical vagueness is here escaped, and we have to deal with tangible and definite results that are dependent upon established laws. The body is thus brought into account, and we see how education, or mental development, is so deeply complicated with physiological conditions, that these can never be neglected in the intelligent consideration of mental culture.

At the close of this special essay, Dr. Clarke appends a mass of valuable testimony in regard to the practical workings of the system of co-education. The short article in our preceding pages, which we have entitled "Educated to Death," is taken from this portion of Dr. Clarke's book. By direction of the State Board of Health of Massachusetts, Dr. F. Winsor, of Winchester, collected some valuable statistics on "School Hygiene," and the effects of co-education formed one feature of the investigation. Circulars were sent to physicians, teachers, and others in the State, soliciting information in answer to questions. Replies were received from one hundred and sixty persons, of whom one hundred and fifteen are stated to be physicians; nineteen, physicians and members of school committees; fourteen, teachers of experience, and six, superintendents of schools. The Board requested that all the replies should be "based on personal observation." The question, "Is one sex more liable than the other to suffer in health from attendance on school?" was answered substantially as follows:

Females more liable than males, by.....	109
Males more liable than females, by......	1
Both alike liable, by....................	31
Neither is in danger, by................	4
Not in district schools, by..............	1
Not if both sexes exercise alike in the open air, by........................	1
Unable to answer, by..................	5

To the question, "Does the advent of puberty increase this liability?" the answers came:

Yes, by..............................	120
No, by................................	12
Uncertain, by.........................	9

Many of the correspondents accompanied their replies with comments which were mostly in the following strain:

"The female scholars are more susceptible to emotional influences, and if there be stimuli in school, appealing to pride and vanity, they are so emulous as to injure themselves."

Again: "This baleful result becomes very strikingly manifested as the girls approach the age of puberty. Under the abnormal conditions of the physical system produced by this cause, not only do the more emulous and studious girls suffer from the study which they evidently ought to intermit, but the ordinary and habitual task-work necessary to keep abreast of the studies is far too severe a draught on many constitutions."

Again: "This greater liability in the female is an *established fact;* and our State and local School Boards should at once take steps to modify our system of education in accordance with the fact, however great may be the change required."

From various communications received by Dr. Clarke with reference to the workings of co-education, we extract the following from that of D. H. Cochran, LL. D., the distinguished head of the Brooklyn Collegiate and Polytechnic Institute, who had ten years' experience of co-education in the New York State Normal School. Dr. Cochran says it had been observed that a large number of students who left the institution were unfitted for teaching by impaired health, so that Dr. Woolworth made an appeal to the commissioners "to send only such students to the school as possessed a sound physical organization. . . .

"Notwithstanding his earnest efforts, the evils of failing health on the part of our female pupils continued, and the consequent incapacity to discharge the duties for which the State was educating them. But the facts were hardly suspected until suggested accidentally, in 1866, and then the reports of Dr. Bailey, who had been consulted by a large number of the female pupils, and of a lady in the faculty of the school, revealed the astounding fact that, among about one hundred and eighty female pupils then in the school, there were over twenty cases in which the periodical functions peculiar to the sex had ceased for over two months, and that there was a much larger number of similar cases, less serious. Even then, the causes were attributed to stairs, bad ventilation, and recklessness of health, without suspicion that the evils were inherent in a system which imposed upon the female continuous labor, and in amount equal to that of the male, who was in many, and perhaps in the majority of cases, her intellectual inferior, but who was the inheritor of continuously rugged health. . . .

"The logic of facts, to which our eyes were so slowly, and I fear unwillingly, opened, finally led to a more elastic course, optional to the females. But, while this gave relief to a part of the pupils, it augmented the evils to others; for the more ambitious regarded the exemption from advanced mathematics as a reflection upon their intellectual ability, and persisted in taking the severer course in spite of the advice of their teachers. . . .

"This spirit was indicated in the remark of one of these pupils to a lady-teacher who was advising her to drop the mathematics of the senior year, on account of failing health. She said, 'I will do it, if it kills me.' We can hardly wonder that the teacher impatiently replied: 'If it killed you, perhaps it would not so much matter; but are you quite willing to impose upon your friends the burden of your lifelong helplessness?'

"I urge the separate higher education of females solely upon physical grounds. My experience has forced me to this. I have a record of my former pupils who stood high in their classes, who did their work with seeming ease, but who have been unable to teach, and now confess that they date the beginning of their present sufferings to the continuous labor of school. I have in my mind, as I write, the case of a young lady from Tioga County, now residing in this city, who stood foremost in her class, and without apparent effort, but who has never been in sound health since her graduation; and she attributes her present condition to the insensible exhaustion of her class-work. Yet she would have been the very last to confess overwork while a pupil; and I do not think that either she, or her teachers, then suspected it."

L'Astronomie Pratique et les Observatoires en Europe et en Amérique depuis le Milieu du XVII[e] Siècle jusqu'à nos Jours. Par C. André et G. Rayet, Astronomes Adjoints de l'Observatoire de Paris. Première partie.—Angleterre. Paris: Gauthier-Villars, 1874.

(Practical Astronomy and the Observatories of Europe and America, from the Middle of the Seventeenth Century until the Present Time. By André and Rayet, Assistant Astronomers in the Paris Observatory. Part I.—England.)

This is the first of a series of three volumes to be published for the joint authors, who are both skillful and able astronomers, known in the scientific world by various important researches. This volume treats of the observatories of England alone, and it is to be followed by two others treating of those of Scotland, Ireland, the Continent, and America.

The design of the work is most excellent, and its execution is thoroughly good, as indeed might have been anticipated. In brief, the plan of the authors has been to give a short history of each of the many institutions devoted to practical astronomy, with a sketch of the life and works of each of the directors who has been in charge of it, as well as an account of the principal instruments and the uses to which they have been devoted.

Quite a number of very good woodcuts are supplied, which give perspective views of some of the most important instruments, and these alone lend great value to the book. Many of these cuts are derived from engravings given in the publications of the various observatories, and they are therefore accessible to all who can consult any of the great libraries; but the collection of these into one volume is a great convenience.

Quite a number of the cuts, however, must have been copied from photographs privately distributed, which, of course, are not generally accessible, nor widely known, and for the reproduction of these we cannot be too grateful. We may instance the extremely interesting cut of Mr. Newall's great telescope of 25 inches aperture (made by Cooke, of York), which was the largest refractor in the world until the mounting of the Clark telescope at the United States Naval Observatory at Washington, in 1873.

A propos of large telescopes, the authors tell us that the two large disks of glass (30 inches in diameter) which have been in the possession of the Paris Observatory since 1855, are shortly to be ground into lenses and mounted, so that, provided the operation of grinding is successful, and no unknown flaws in the glass exist, Paris will soon have a larger equatorial than any now mounted.

Americans, however, may console themselves with the thought that the magnificent gift of Mr. Lick, of San Francisco ($700,000), will soon become available "to construct a more powerful telescope than any now in the world," and they may safely trust to the artistic skill and to the scientific sagacity of the Clarks, to whom the work will undoubtedly be confided, to make the most perfect instrument yet known.

The book treats largely, too, of the history of the private observatories of England, and it is no small convenience to have gathered into one volume material which, if in print at all, is scattered through many volumes of rare periodicals and books.

In this volume 50 pages are devoted to the Observatory of Greenwich alone, and then follow accounts of those observatories which belong to universities, to learned societies, or to cities; and, finally, 80 pages are concerned with the observatories of private gentlemen.

It will be seen that this is a very full account, and we may say that, besides being a book of great interest to the astronomer, it will be highly interesting to the general reader who is anxious to be informed about this important subject.

We notice very few omissions: the most striking one, however, is the absence of any account of the Bedford Observatory, of Admiral Smyth, which should be notable if only as the birthplace of the "Bedford Catalogue," one of the most curious of astronomical publications.

Perhaps the omission of the celebrated catalogue of "Double Stars" from among the works of Mr. Dawes, the noted observer of double stars, might also be mentioned.

But these are minor points, and do not prevent the book from being a perfect success, creditable to its authors, and a valuable contribution to the literature of astronomy.

We look forward with eagerness to the appearance of the remaining two volumes.

It is to be hoped that the book, or at least that part of it which refers to the observatories in the United States, may be translated into English, for the use and information of many Americans who will not see the original French edition.

Since Loomis's "Recent Progress of Astronomy in the United States," nothing of importance has been published here, on this subject, if we except two papers on observatories in the United States, which have recently appeared in *Harper's Magazine*.

There undoubtedly exists among Americans a very strong interest in astronomy generally and in the doings of observatories, and a greater knowledge of the many institutions of this kind in the United States would undoubtedly lead to more intelligent and concerted action on the part of the private gentlemen who own them.

For example, if a person who has a fine meridian instrument knows that the Harvard-College Observatory is observing a certain zone of stars, he will not commit the folly of wasting his time and his labor by doing the same work, but will rather turn his attention to something which is yet undone. To know what is yet undone is often the question, and this book supplies in a measure the want, for it tells us what is doing.

Perhaps this is as good a place as any to call the attention of amateur astronomers to the important work which they may do, if they will only choose some special subject, make themselves familiar with what has been done in it, and then devote even a small portion of time to its *regular* and *systematic* pursuit.

Numerous examples of such valuable work done by amateurs are to be found in the book before us: and in many cases this work was done by gentlemen who were not able to devote their whole time, or any thing like it, to astronomy.

Dawes, the great double-star observer; Carrington, the assiduous observer of circumpolar stars, and of solar spots; Lassell, the great physical astronomer; with De La Rue, Huggins, Lockyer, and others, have done permanent good to science, and have acquired great reputation, while most of them followed other pursuits.

And we may hope that such knowledge as is attainable from this book will induce American amateurs to limit themselves to some useful but special inquiry in which they may gain credit, and render useful service to astronomy. E. A. H.

The Journal of Speculative Philosophy, July, 1874. Quarterly, whole number 31. Price 50 cts. a number, or $2 a year. Edited and published by William T. Harris, St. Louis, Mo.

This periodical, which has come to be recognized as the organ of speculative thought in this country, has now reached its eighth volume, and the series forms a philosophical library of great value to metaphysical students who keep up their interest in abstract and abstruse inquiries. It is the policy of the editor to make his periodical not so much a vehicle of contemporary speculation as a summary of the doctrines and expositions of the greatest philosophical thinkers of past times. Accordingly, the published volumes will be found largely occupied by essays and discussions from the writings of such men as Leibnitz, Descartes, Kant, Fichte, Schelling, Hegel, Goethe, Rosenkrantz, Schopenhauer, Hartmann, Herder, Trendellenburg, and others. From such writers we have in the pages of this magazine an authoritative and all-sided presentation of metaphysical questions, such as can be otherwise obtained only by ransacking extensive libraries. An important feature of the magazine is the considerable space it devotes to the criticism and interpretation of the works of art, poetic, dramatic, musical, pictorial, architectural, etc.

The first article of the July number of this magazine is an addition to the voluminous literature of Shakespearean criticism, by D. J. Snider. In an acute and ingenious analysis of "The Tempest" the author aims to show that this drama is a profound philosophical study of two worlds, the real and the ideal. As it is latterly the fashion for lawyers, doctors, and scientists, to find every thing in Shakespeare as fast as it is discovered elsewhere, so the present writer would seem to assume that the poet had anticipated the last results of German metaphysics. Will not this vein at length give out? Daniel Wilson has lately been over the same ground, and devoted a solid volume to prove that in "The Tempest" Shakespeare has anticipated the modern doctrine of Evolution. Among the questions debated by the schoolmen of the middle ages, the following is reported: "Was Adam, while yet without sin, acquainted with the '*Liber Sententiarum*' of Peter Lombardus, Bishop of Paris?" It would seem to be an open question with many of our later commentators and schoolmen, whether Shakespeare may not really have been acquainted with the works of Darwin and Hegel! "The Music of Color," the second article, is an ingenious and instructive statement of the analogies of light and sound as explicable on the wave-theory. Many efforts have been before made to find harmonic relations between the spectrum and the gamut, but the results have been regarded as unsatisfactory. The present writer presses the analogy in many particulars, and is confident that it will ultimately be fully established. In the third article Prof. Vera treats of "Ideas as the Essences of Things." He takes the high Platonic ground of independent and eternal ideals, saying: "The force that produces the plant, and according to which the plant grows and dies, is its idea. The réal and absolute germ is not the individual and external germ we touch and see, but the idea by which the external germ is created and endowed with the necessary force for its growth and preservation." "Thoughts on the Intellect" is a translation from one of the powerful works of Schopenhauer, in which that pestilent old pessimist puts the entire philosophy of things in the following nut-shell: "The laws and powers of Nature, together with matter in which they inhere, constitute here the given, and consequently the absolute real, taken generally; but regarded specially, as innumerable suns and planets, floating in infinite space. These are therefore, as the result, everywhere, nothing but balls, a part of which are shining, the rest illuminated. Upon the last, life has unfolded itself in consequence of a process of putrefaction, which, in gradual succession, produces temporary organic beings, rising and perishing through generation and death according to the laws of Nature governing the power of life, which, like all the others, make up the reigning (and from eternity to eternity) existing order of things, without beginning or end, and without giving account of themselves. The highest point of this succession is occupied by man, whose existence also has a beginning, in its course many and great miseries, few and parsimoniously-granted joys, and after this, like every thing, has an end; after which, it is as if it never had been."

Mr. Stephen Pearl Andrews contributes a paper on the "Revisal of Kant's Categories." He is the author, as is well known, of an elaborate philosophical system which he denominates "Universology," and one of the features of which is a universal language. Mr. Andrews is a philosophical linguist, and his studies have brought him to the conclusion that there can be no comprehensive and perfected system of philosophic thought that does not include some means of systematic security against the errors which arise from the defects of language and the multiplicity of tongues. In the present paper he takes the "categories" arrived at by the transcendental analysis of Kant, and seeks for those elements and conditions of the structure of language which correspond to these categories. He says: "The three categories of quantity are Unity, Manifoldness, and Universality, which are no more than the same ideas which, in respect to grammar, we indicate by the terms 'singular, plural, and common.'" He then proceeds to trace out other analogies or correspondences, and shows that grammar throughout has its true basis in logic.

The number before us of the *Journal of Speculative Philosophy* contains other articles, as an analysis of the music of "Robert Schumann," Herbart's "Rational Psychology," and various minor discussions, but the essays noticed will give an idea of the scope and variety of the subjects treated in its pages. If it be thought that this magazine is too sublimated in its speculations for practical service in this age, we must remember that the age needs improving; that the tendency of all science is toward the establishment of generalizations or abstract principles; and we must not forget that this journal is edited by one of the most able and thorough of the practical educators of the country.

One Year of Science. Tribune Publication. Price, 25 cts. Contents: Scientific Views of Comets; Philological Convention of Hartford; Chemistry's Centennial; American Science Association of Hartford.

This pamphlet of 92 large pages, double columns and in small type, contains an immense amount of miscellaneous scientific information boiled down to a state of concentration that is only equaled by the cheapness for which the whole is sold. There are nearly 150 articles, many of them quite full, some of them illustrated, and all of them on the latest aspects, results, and tendencies of contemporary science. In its series of cheap scientific publications, freighted with useful information for the people, the *Tribune* is doing an important work of popular education, and deserves to be widely and liberally sustained.

Exposures in Fire-Insurance. By William Frazier Ross. New York: D. Appleton & Co.

In the language of fire-insurance, all insurable property is subject to certain exposures or liabilities to take fire. For instance, a building so situated in relation to a storehouse of oils or spirits, that, were the liquids to take fire, they would flow toward it, is therein subject to an exposure. Exposures are numerous and varied in kind, and upon the number and quality of those to which a building is subjected does its rate of premium depend. This makes apparent the necessity for a reliable method of estimating the exposures. The difficulty hitherto in the way has been want of statistics, and this deficiency it is the object of this little volume to supply. In the main, it fulfills its purpose, but the habitual use of technical terms, without explanation of their meaning, and the occasional occurrence in close proximity of a word, first in its technical and then in its common acceptation, is calculated to confuse the general reader. By its use, property-holders will be enabled to estimate for themselves the cost of insuring their property, and thus to establish a check on over-charges.

An Introduction to the Study of General Biology. By Thomas C. MacGinley. New York: G. P. Putnam's Sons. 198 pages. Price, 75 cents.

This is an ambitious attempt to supply what is still needed—a good text-book on biology for schools. The author deals extensively with the torula, or yeast-plant, bacterium, protococcus, and other low forms of life, and gives but a single example of the three highest branches. In this respect the subject-matter of the book is not properly balanced. While there is much to commend, there is much to object to in the obscure and shocking character of many of the figures, as being more likely to mislead than to aid. Many of them look faithful copies of hasty and crude pencil-notes of hasty and crude drawings made on the black-board.

Statistical Atlas of the United States. Part II. Population, Social and Industrial Statistics.

This is part of a series of large folio maps intended to represent, graphically, first the progress of the United States, both as regards acquisition of territory and increase of population, and then the relative proportions of the various race-elements. To the illustration of these subjects are devoted sixteen sheets of the atlas. The remaining eleven sheets represent the ratio to total population of illiteracy, of church accommodation, of producers, etc., and the distribution of wealth, public indebtedness, taxation, revenue, expenditures, and agricultural products.

The Transit of Venus. By George Forbes, B. A. Macmillan & Co. 99 pages. Price, $1.25.

This timely little volume was contributed in installments to *Nature*, and these are now collected and issued in the neat form of Macmillan's "Nature Series." It gives an interesting account of the general subject, first, in its historical aspect; second, the scientific conditions of the problem; third, the preparations for solving it by the different nations. The volume is copiously illustrated, and will meet the wants of general readers who wish to know something about the great scientific event that is to happen in December. At the close of the third chapter, the author thus recapitulates the technical view of the subject:

"1. We know the *relative dimensions* of the solar system accurately; but we do not know the *scale*.

"2. The determination of the distance of the earth from the sun, or from any of the planets, at a fixed date, fixes the scale.

"3. This may be determined (1) by the aid of a transit of Venus; (2) by an opposition of Mars; (3) by a knowledge of the velocity of light, combined with observations of eclipses of Jupiter's satellites; (4) by the velocity of light and the constant of aberration; (5) by the calculated effects of the sun's disturbance upon the lunar motions.

"4. A transit of Venus may be utilized:

"(*a*.) By the determination of times of contact at different stations, combined with a knowledge of the longitudes of these stations.

"(*b*.) By determining the least distance between the centres of the sun and Venus during the transit, observed from different stations.

"5. This last determination may be made by any of these methods:

"(1.) The photographic method.

"(2.) The heliometric method.

"(3.) The method of durations."

A Work of Great Importance.—The twelfth volume of the "International Scientific Series" is contributed by Dr. John W. Draper, and will be a "History of the Conflict between Religion and Science." It might seem strange that such a history has never been written before, but the subject has had to wait for the historian. It is doubtful if there is another man living besides Dr. Draper who has had the peculiar preparation necessary for executing so difficult a task. Dr. Draper's familiarity with science is extensive. He has cultivated large tracts of it as an original investigator, and with a success that has given him a world-wide reputation. He has also been a life-long student of history, and has considered his questions largely from his point of view as a student of Nature. Dr. Draper's "History of the Intellectual Development of Europe" is one of the great books of this age; and that it is so appreciated is shown by the fact that it has been translated into nearly all the languages of Europe. The study of the problem of the intellectual development of man which has taken place in Europe in historic times, was a grand preparation for treating the special relations of religion and science in their historic aspects. The volume is written in a remarkably clear and attractive style, suitable for all readers, and it abounds in fresh and striking views, vividly and boldly presented. Dr. Draper's book is certain to make a profound impression upon the public mind.

Professor Tyndall's Belfast Address. With Preface and Additions, by the author. First authorized and revised edition. D. Appleton & Co. 68 pages. Price, 25 cents.

In the Preface to this complete edition of his Address, Prof. Tyndall says that it was written in the Alps, and was sent home in installments to be printed; but, being too long for oral delivery, he was compelled to omit certain parts, while only what he read was given to the public. The omitted passages are now supplied, the whole has been thoroughly revised, and a Preface is added in which the Professor pays his respects to some of his detractors. Regarding one of these imputations, he says: "In connection with the charge of atheism, I would make one remark. Christian men are proved by their writings to have their hour of weakness and of doubt, as well as their hours of strength and of conviction; and men like myself share, in their own way, these variations of mood and tense. Were the religious views of many of my assailants the only alternative ones, I do not know how strong the claims of the doctrine of 'material atheism' upon my allegiance might be. Probably they would be very strong. But, as it is, I have noticed, during years of self-observation, that it is not in hours of clearness and vigor that this doctrine commends itself to my mind; that in the presence of stronger and healthier thought it ever dissolves and disappears, as offering no solution of the mystery in which we dwell, and of which we form a part."

PUBLICATIONS RECEIVED.

Geological Survey of Indiana. By E. T. Cox. Pp. 494.

Yellow Fever Epidemic of 1873. By Jerome Cochran, M. D. Montgomery, Ala. 1874. Pp. 115.

Bulletin of the Buffalo Society of Natural Sciences. Vol. II., No. 2. Pp. 40.

Transactions of the Wisconsin Academy of Sciences, Arts, and Letters. 1873–'74. Pp. 254.

Double Stars. By S. W. Burnham, Esq. Pp. 13.

Catalogue of Forty-seven New Double Stars (same author).

Molecular Change in Iron and Steel by Electric Currents. By John Trowbridge. Pp. 16.

Freeing a Magnetic Bar from Earth's Magnetism (same author). Pp. 8.

Increase of Magnetism in Soft Iron by Reversal of Magnetizing Current. By W. A. Burnham. Pp. 9.

MISCELLANY.

Artificial Butter.—The *American Chemist* for April contains a very full account of the manufacture of artificial butter, of which the following is a synopsis: Some years ago M. Mege Mouriez was commissioned by the French Government to make some researches with a view to obtain a product suitable to take the place of ordinary butter, to be sold at a much lower price, and capable of being kept without becoming rancid. M. Mege Mouriez placed several milch-cows on a strict diet. The animals were quickly reduced in weight, and gave a proportionately less amount of milk; but this milk always contained butter. Where could it come from? M. Mege Mouriez believed it was produced from the fat of the animal, which, being carried into the circulation, was deprived of its stearine by respiratory combustion, and furnished its oleo-margarine to the udder, and there, under the influence of the mammary pepsin, it was changed into butyric oleo-margarine, or butter. Guided by this observation, M. Mege Mouriez was not long in obtaining, by an ingenious process, from beef-suet a fat fusible at nearly the same temperature as butter, and of agreeable taste. He then transformed this same fat into butter by a process similar to that of Nature. His process is as follows: The fat of newly-slaughtered beef, of the best quality, is ground up between two cylinders, and then falls into a deep vat heated by steam, and containing for every 1,000 kilogrammes of fat, 300 kilogrammes of water, and one kilogramme of potassic carbonate, besides two sheep's or pigs' stomachs in small pieces. The temperature is then raised to 45° Cent. and the mass carefully stirred. At the end of two hours the fat all rises to the surface. It is then let off into another vat, heated on a water-bath to 30° or 40° Cent., and two per cent. of sea-salt added, to facilitate the depuration. In the course of two hours it becomes clear, and presents a fine yellow color, and the odor of freshly-churned butter. Having been carefully cooled, it is cut into cakes, packed in linen, and placed under an hydraulic press, and is then separated into two nearly equal parts, viz., stearine and liquid oleo-margarine. The stearine is used for making candles. After cooling, the oleo-margarine is passed through cylinders under a shower of water to wash it and give it consistence: it constitutes an excellent cooking-grease.

It is with oleo-margarine that M. Mege Mouriez, by operating in the following manner, makes his cheap butter: To 50 kilogrammes of melted oleo-magarine in a churn he adds about 25 litres (26 quarts) of cow's milk and 25 kilogrammes of water containing the soluble parts of 100 grains of the mammary gland of the cow. The churn is then set in motion, and in fifteen minutes the grease and water become transformed into a thick cream, which in turn is changed into butter. The churning being ended, water is poured in and the butter separates, containing buttermilk, which must be removed. The product is then placed in a sort of kneading-machine composed of two cylindrical crushers, and placed under a stream of water. There it is worked in a way to change it "into well-washed butter of fine and homogeneous appearance."

The Todas.—A traveler in Southern India, Colonel Wm. Marshall, in a work recently published, makes the world acquainted with a very singular tribe of men, the Todas, who inhabit the plateau of the Nilghiri Hills. The Todas live in very small village communities of from twenty to thirty persons. Attached to every village is a cattle-pen, and a separate building, which constitutes the dairy and the dairyman's abode. Their life is purely pastoral, and their sole dependence the buffalo. Though the land is fertile and the climate delightful, they do not practise agriculture at all; and though their hills abound in game, they neither hunt nor trap any living thing. Their only domestic animals are the buffalo and the cat. They eat no flesh, living wholly on milk and butter, with rice and other vegetable food obtained in exchange from the surrounding population. Though on all sides they are hemmed in by strong and often quarrelsome tribes, they possess no weapon of offense; they never fight among themselves or with their neighbors. They have no manufactures. Two men in every village are set apart for the dairy-work, leaving all the rest to lead an almost absolutely idle life. The Todas are quiet and dignified in their manners, amiable in disposition, and very good-looking. Their absolute dependence on the buffalo has led them to form a religion in which this animal is the central figure. The dairy is sacred, and no one except the dairyman and his assistant is permitted to enter it. During the term of office these two men have to pass absolutely retired and celibate lives, they and their implements being touched by no human being. They keep in the dairy certain relics—old cow-bells, knives, and axes —which are in the highest degree holy, and these the dairyman-priest salutes every morning with certain ceremonies. The people in general also salute the setting sun, and have some vague notions of a future state.

The Todas number at present only about seven hundred souls. Formerly they practised infanticide, but for some years this has ceased, and the tribe is now increasing in number. The primitive custom was to kill all female children of a family except one or two. The result was of course an excess of males, and hence sprung the custom of one woman having many husbands. This practice still continues. The census tables seem to show that considerably more male than female children are born. It is worthy of note that, although from time immemorial consanguineous marriage has been the rule among the Todas, still not more than one per cent. are malformed.

Tea-Adulterations.—One of the usual ways of adulterating tea is by the admixture of leaves other than those of the tea-plant. For the detection of these foreign leaves, but little aid can be given by chemistry, and it is best to study their botanical and microscopical characters. Prof. Alfred H. Allen gives, in the *Chemical News*, the following method for detecting adulterations of this kind: "Some of the sample to be examined," says he, "is to be put in hot water, and when the leaves have unfolded, they are spread out on a glass plate and held up to the light, when the venation, serration, etc., are readily observed. The primary venation of the tea-leaf forms a series of well-defined loops, which are not met with in most leaves used as adulterants. The serrations are not mere saw-teeth on the margin of the leaf, but actual hooks. The serration stops short, somewhat abruptly, at some distance above the base. The Assam tea-leaf is sometimes bi-serrate. At the apex of the tea-leaf there is a distinct notch, instead of a point. If we examine the under surface with the microscope after the separation of the cuticle, the peculiar and characteristic space between the two cells of the stomata is readily perceived. The long unicellular hairs of the tea-leaf are also peculiar. The employment of caustic potash is desirable in observing these characters.

"In the *sloe-leaf* the serratures are direct incisions, numerous, often irregular, and extending down to the base. There are no spines. The hairs are shorter and coarser than those of the tea-leaf, and are marked in a peculiar manner. The *elder-leaf* is more pointed than that of the tea-plant, and the lobes are unequal at the base. The serratures are direct incisions. The midriff has hairs on it, and on the leaf itself there are several kinds of hairs, notably a short, spinous, striated hair, which occurs on the upper surface. The serratures of the *willow-leaf* much resemble those of tea, but the cell-walls of both the upper and under epidermis differ from those of the tea-leaf in not being sinuous, and there are long, coarse, striated hairs. When perfect, the elongated form of the willow-leaf sufficiently distinguishes it from tea, and the venation is also entirely different. The chief foreign leaves added by the Chinese are those of *Chloranthus inconspicuus* and of *Camellia sasanqua*, the latter of which presents a close resemblance to the tea plant."

Usefulness of the Robin.—Pitying the ignorance of farmers, and country-people generally, touching the habits and usefulness of the robin, and pitying equally the poor bird itself for the abuse which this ignorance brings upon it, Caroline Bryce, in the April *Naturalist*, has rendered a service to both by pointing out in a very interesting way the value of the bird to the country, and the mistake that is made in attempting to drive it from our fields and groves. "The robin has two broods in a season, each brood varying in number from two to five. The young are fed exclusively on insects, and their rapid growth and consequent voracity, only equaled by the larvæ stage of insect-life, makes an abundant supply of insect-food an indispensable requirement. The food of the mother-bird is also chiefly insects, and this double demand makes the robin a valuable assistant to the farmer and horticulturist in keeping under insect pests. Regarding its supposed habit of cherry-eating, the author is of opinion that it is attracted chiefly by the color of the fruit, and not by any special liking for it as food; that it picks the cherries for the same reason that it picks to pieces a red flower. Instead of being an enemy to the cherry-crop, it is in reality a most important aid in securing an abundant supply of healthy fruit. If I should venture to say that not a cherry would grow, fit to be eaten, were it not for the birds, the bare idea would be hooted as preposterous, yet such, nevertheless, is my belief. Were it possible to remove all the birds out of the way, for one season at least, what a decided difference would our future orchards present! Where now are thrifty growths, beautiful leafage, and large crops of fair fruit, would be seen stinted, moss-grown limbs, with sparse or meagre foliage, crops of dwarfed specimens, that have finished their growing, in a knotty, wormy, inferior state. The majority of all the large families of insects are bred in the earth, and go through various forms in different stages of existence, and are devoured by birds of every description, chief among which stands our friend the robin."

How Leaves are blanched by Bright Sunlight. — The leaves of certain plants grow pale in the full glare of the sun, and it becomes a question whether this change is due to a diminution of the amount of chlorophyll. Mr. H. C. Sorby has repeatedly analyzed the leaves of such plants, but the result showed that sunlight or shade makes no difference in the quantity of the chlorophyll. He therefore came to the conclusion that the change in color is due to some mechanical alteration in the structure of the leaves. This conclusion is confirmed by the independent researches of a French observer, Prillieux. According to the latter, exposure to bright light causes both granular and amorphous chlorophyll to collect together at the sides of the cells, instead of being more evenly distributed. The result is, that a much larger relative quantity of white light is reflected, and the leaves appear of a paler and whiter green.

Fossil Horses.—In the *American Naturalist* for May, Prof. O. C. Marsh has an article on "Fossil Horses in America," in which he says that the remains of equine mammals hitherto found in the Tertiary and Quaternary deposits of this country represent more than double the number of genera and species occurring in the strata of the Eastern Hemisphere. It is in ancient lake-basins of Wyoming and Utah that the oldest equine remains have been found. These belong to the genus *Orohippus*, and are of diminutive size, hardly larger than a fox. The skeleton of these animals resembled that of the horse in many respects, but, instead of a single toe on each foot, the various species of *Orohippus* had four toes before and three behind, all of them reaching the ground. Of *Orohippus* Prof. Marsh has found four distinct species. The genus *Miohippus* makes its first appearance in the Oregon basin. It is distinguished from the *Orohippus* chiefly in that it has only three toes in the fore-foot, as well as behind. In this genus all the toes reached the ground. In the same deposits the genus *Anchitherium* occurs, being represented by a single species. The animals of these two genera are all larger than *Orohippus*, some of them exceeding a sheep in size. Of the Pliocene genera more than twenty species have been described, all apparently larger than their Miocene relatives just mentioned, but all smaller than the present horse. In the Upper Pliocene, or more probably in the transition beds above, there first appears a true *Equus*, and, in the Quaternary, remains of this genus are not uncommon. Thus there is a continuous development in the direction of the modern horse, and it seems very strange that none of the species should have survived.

Tidal Influence on Vegetable and Animal Life.—The following dispatch was sent by A. N. Duffre, United States consul at Cadiz, Spain, and communicated to the Department of Agriculture by the Secretary of State:

A Madrid paper, entitled *La Epoca*, has published an article signed by Don Luis Alvarez Alvistur, on the influence of the tides on vegetation, in which the writer announces a new theory, based on the results obtained during fourteen years devoted to experimental research, by an enlightened landed proprietor of Lorca, in the province of Murcia.

The theory adopted was the direct influence of the tide on the circulation of the sap, and its experimental application, after determining the meridian of the estate, and tabulating the corresponding hours of ebb and flow, has been the felling and lopping of forest-trees solely during the hours pertaining to the ebbing tide. The results are stated to have been conclusive, the decay annually observable formerly in some portion of the timber having ceased completely in the many years that have elapsed during the application of the new principle. The system was then applied to an olive-grove, the yield of which had ceased to cover the annual costs of culture, by removing every dried portion of the trees exclusively during ebb-tide. The result is stated to have been the complete transformation of the grove, a great development of foliage, and abundant crops.

Equally admirable results ensued from the similar treatment of orange, lime, and other fruit-trees, which were thenceforth unaffected by larvæ or other plagues which smote adjoining orchards; and, finally, the vineyard of the Lorca landlord, though surrounded by those of other proprietors which were devastated by the *oidium*, a microscopic fungus which appeared in the district at the period when the new system was first essayed, has never exhibited the faintest trace of the presence of the malady.

It is likewise asserted that experiments, made with equal sets of silk-worms, respectively fed on leaves of trees treated by the ordinary and by the new system, the leaves under the new plan being gathered exclusively at the hours corresponding to the ebb-tide, resulted most decidedly in favor of the latter.

How the Fuegians keep warm. — In "A Memoir of Richard Williams," an English missionary to Patagonia, occurs the following passage:

"When clothing is scanty, by the same providential management which coats the whale in frozen seas with oil, the Fuegian is fortified against his inclement sky by an abundant development of the adipose tissue; and, though his sea-otter or guanaco cloak is somewhat scanty, in admiring his handiwork, we must not forget that inside his skin he wears a thick underclothing of non-conducting fat. Hence these islanders sometimes exhibit feats, the recital of which is enough to make us shiver. In the coldest midwinter they may be seen diving for sea-eggs; and it was on a dark night, when the thermometer was at 25°, that some of them swam from the shore, and from its mooring alongside cut away the ship's boat of the Adelaide."

Drought and the Potato-Disease.—A writer in the *Gardeners' Chronicle* observes that every outbreak of the potato-disease, since 1845, has been preceded by a long term of dry, warm weather, followed by heavy rain late in July, or during August. Hence he concludes that this disease must be caused by the carbonic, sulphuric, nitric, and other acid matters, which are constantly accumulating in the atmosphere during dry weather, until they unite with showers of rain, by means of which they are deposited upon plants and soil. As the leaves of plants are their lungs, and the potato is a tender plant, the poisonous atmospheric acids of summer droughts, thrown down by heavy rains, quickly act upon the holms. The surest remedy appears to be, to dig the potatoes, and store them before the summer rain commences, provided they are nearly ripe—that is, when the stalks begin to wither, or when the skin of the tuber cannot be rubbed off with the thumb.

NOTES.

During the Khivan expedition, the Russian army was fed chiefly on biscuits composed one-third of rye-flour, one-third of beef reduced to powder, and one-third of powdered sauerkraut. The men are said to have had a great relish for this food, and their good health during the expedition is attributed, in great part, to the use of it.

In his address before the Congress of Orientalists, Max Müller claimed that, during the last 100 years, Oriental studies had contributed more than any other branch of scientific research to purify the intellectual atmosphere of Europe.

An exhibition of very considerable interest is to be held in Paris in September and October. It will consist of all the useful insects and their productions, and of the noxious insects, and specimens of the injury they do. Each species is to be shown, when possible, in its several stages of egg, larva, chrysalis, and perfect insect. The exhibition will be under the auspices of the Central Society of Agriculture and Entomology.

Prof. Jeffreys Wyman, of Harvard University, died at Bethlehem, N. H., September 4th, aged sixty years. The deceased was, for twenty-seven years, Hersey Professor of Anatomy at Harvard, and of Comparative Anatomy in the Lawrence Scientific School. His published works consist of numerous articles on anatomy and physiology contributed to scientific periodicals and learned societies.

The Austrian Polar Expedition, which, for some time, has caused such anxious apprehensions, has at last been heard from. The expedition was shipwrecked, and spent two winters upon the ice. The highest latitude reached was 83°. Hall's highest latitude was 82° 16′. A large tract of land was discovered northward of Nova Zembla. Only one death occurred during the whole time from the sailing of the expedition, in 1872, to their arrival at the Norwegian island of Wardoe in September of the present year.

Tissandier finds the quantity of solid matter contained in a cubic metre of Paris air to vary between 6 and 23 milligrammes. Where this matter consists of *débris* of wood, coal, or the like, the corpuscles reach sometimes a length of $\frac{1}{10}$ millimetre; where of mineral matters, silica, etc., the diameter varies from $\frac{1}{100}$ to $\frac{1}{1000}$ of a millimetre. Analysis of the dust shows: organic matters, from 25 to 34 per cent.; mineral matters, from 75 to 66 per cent. Iron was found in notable quantity.

M. Gréhaut, of the Paris Biological Society, has, for some time, employed a method of producing anæsthesia by means of chloroform, which gives very satisfactory results, and produces complete anæsthesia, for any required length of time, without danger to life. To this end, he administers to the person or animal to be anæsthetized a quantity of vaporous chloroform accurately determined. He fastens to the muzzle of a dog, weighing say 20 pounds, a rubber bag holding 100 quarts of air mixed with 20 grammes (about 300 grains) of chloroform in the state of vapor. The animal breathes this confined atmosphere, and anæsthesia is produced in the course of from five to ten minutes. It may be protracted for over two hours. With this amount of chloroform the anæsthesia is complete, and, in proportion as a fraction of the vapor is eliminated from the lungs, an equal quantity is absorbed by the same organ.

Silicious and calcareous rocks are more commonly broken up by chemical than by mechanical action, but the contrary is the case with felspathic and slate rocks. For subaqueous structures silicious stones are generally preferable to those of a calcareous nature.

An electro-magnetic copying-machine has been devised by Hencker, of Munich, which transmits by telegraph, and that, too, without the assistance of an operator, writing, portraits, plans, maps, etc. An impression of the object to be copied is taken with a prepared ink on a sort of silver paper, which is then rolled on a revolving cylinder, and the message, whether in writing or in the form of a drawing, is at once forwarded to its destination, a perfect fac-simile of the writing or drawing being produced at the other end of the wire.

The Paris Acclimatization Society has requested and obtained of Mr. Seth Green permission to publish a French translation of his work on trout-culture.

At Mariupal, Russia, a teacher was recently denounced to the entire parish, by the village pope, as unfit to teach children, owing to his "habit of taking walks on the steppe, and collecting useless grasses, disgusting insects, and every conceivable abomination, and making these things objects of public instruction." This wicked teacher was also censured for his disuse of the rod, and his aversion to the good old Russian practice of pulling out bunches of hair from the heads of refractory children!

The salaries of male and female teachers in the schools of San Francisco have been equalized.

An exhibition was recently made in Scotland of a process of clearing forests by steam. A traction engine of 12 horse-power is stationed some distance from the wood, and a wire chain is fastened to the tree. Steam is then put on, and the tree is pulled forcibly out by the roots. In the course of five hours, upward of 300 trees, in a plantation nearly 100 years old, were pulled out. It is hoped that the method may prove applicable in the clearing of new tracts of forest-land.

From a synopsis communicated to the Philadelphia Academy of Sciences by Prof. Cope, of his work in connection with Hayden's survey in 1873, it appears that the whole number of species of vertebrata obtained was 150, 95 being new to science. The species from the Miocene numbered 75, of which 57 were new.

A French patent has been granted for the preparation of leather from tripe, intestines, and other animal membranes; these are worked in milk-of-lime while still fresh, then washed and immersed in water, and finally in a paste made of starch and white-of-egg. The substance thus formed is to be used for glove-making, etc.; the material may also be tanned or curried.

In 1865 there were in France 4,833 school libraries containing 180,854 volumes; in 1869 the number of libraries was 14,395, and of volumes 1,239,165. At the present time there are (the Seine Department not included) 15,623 school libraries, and 1,474,637 volumes. Notwithstanding the events of the last few years, the state, provinces, communes, and private individuals, have liberally contributed funds for maintaining this important work.

The problem of pure-water supply for London has probably been solved by Mr. J. Lucas, of the Geological Survey. Examining the green sands and chalk of Surrey, he finds over 1,000 feet of porous strata resting on absolutely impervious clay. He contends that a tunnel driven along the strike of the beds, or water-level, must arrest all the water that is flowing down as far as the gallery is carried.

The question whether snakes eat toads is answered affirmatively by a writer in *Hardwicke*, who speaks from direct observation. Having discovered a garter-snake in a strawberry-bed, he struck the creature a sharp blow with a stick, and out flew a medium-sized toad. Before the blow, only the hind-feet of the toad were visible, protruding from the snake's mouth.

In removing grease-spots from clothing with benzole or turpentine, the usual way is to wet the cloth with the detergent and then to rub it with a sponge or the like. This only spreads the grease, and does not remove it. The proper method is given by the *Scientific American:* Place soft blotting-paper beneath and on top of the grease-spot, after the latter has been thoroughly saturated with the benzole; then press well. The fat is thus dissolved and absorbed by the paper, and entirely removed from the clothing.

The British Meteorological Society has organized a system of observations of natural phenomena connected with the return of the seasons, as affecting the development of animal and plant life. It is expected that in this way much valuable information will be gained with regard to the influence of climate on plants, insects, birds, and other animals. The Royal Agricultural, Horticultural, Botanical, and other societies of Great Britain, have promised their coöperation in the scheme.

A singular feature of the last illness of Guizot was, that for three weeks previous to his death his memory was totally at fault during the greater part of the day; but from noon till 5 P. M. it was quite perfect, especially if the conversation turned upon his favorite study — the history of France. Again at five he would fall into a kind of somnolence, which lasted till noon of the following day.

The new Reclam-Siemens cremation-furnace has been tested at Berlin with satisfactory results. Two hundred weight of animal carcass was consumed in about 90 minutes, and reduced to white ashes at the cost of less than one dollar. Eighty-two German cities possess cremation societies.

From researches made by Phipson, it appears that thallium is much more widely distributed than has been supposed — as widely, indeed, as lead, he thinks. He has met with it especially in metallic cadmium, and the cupriferous pyrites of Spain and Norway, and in many of the other minerals and industrial products derived from them.

The molar tooth of a mastodon was recently exhumed near Waterloo, Ind. It weighs six pounds, is eight inches long, and has four prongs and four double crowns.

The French Minister of War, General de Cissey, has very positively prohibited the officers of the army from communicating to any scientific body, or publishing in any scientific journal, any "memoirs of a scientific character having reference to any branch of the military service. . . . Such publications," he says, "are absolutely contrary to the 'principles of (military) *hierarchy*.'" The *Revue Scientifique* naturally takes umbrage at this general order, and says that it cannot fail to do injury to the army, by placing it beyond the reach of fair criticism.

The American Museum of Natural History in Central Park, as we learn from the *Tribune*, has lately received the Wolfe memorial gift, which consists of a collection of shells gathered by Dr. J. C. Jay, together with his library of works on conchology. The collection embraces over 10,000 species, and probably 50,000 specimens. The library is supposed to contain every book treating of shells published before 1861, and most of those issued since then. It also contains full sets of the transactions of all the prominent scientific societies.

The Austro-Hungarian Government has decided to send out another expedition next year to ascertain whether "Franz-Josef Land" is part of the continent or an island. The expedition will be divided into two parties, one going by way of Siberia, the other by way of Greenland.

The use of aniline red for coloring hair-oils is condemned by the *Laboratory*, and an instance is cited in proof of the injurious effects resulting from the employment of oils so colored. A man in Boston, who had for some time frequented a barber's shop in which aniline-colored oil was used in hair-dressing, began to experience a disagreeable itching of the scalp, very similar to that produced by arsenic. On inquiry, the trouble was traced to the hair-oil, which contained arsenic present in the aniline color; and, by discontinuing its use, the eruption soon disappeared.

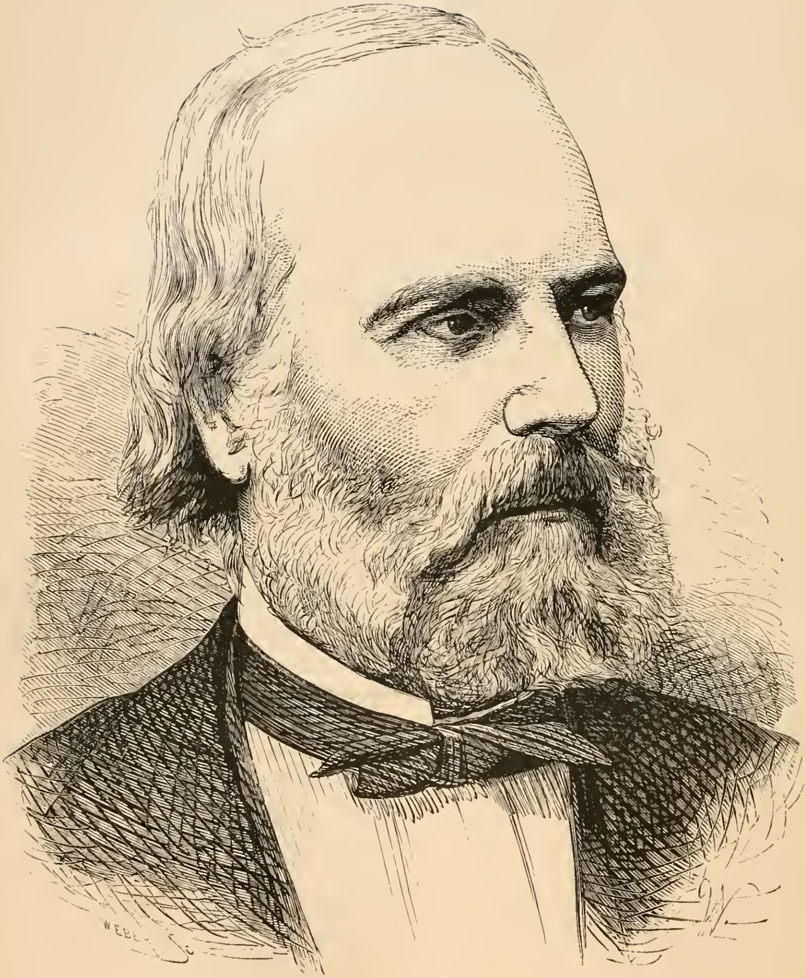
Mr. Richard A. Proctor says of our Signal-Office forecasts of the weather, that they are "singularly accurate, the percentage of error being little more than ten or twelve, and constantly diminishing." During the last three months of his stay in the United States, the weather announcements of the Signal-Office failed of strict fulfillment only twice; and even then the error consisted only in the announcement of a change in the weather a few hours before it actually occurred.

About two-thirds of the estimated cost of the Liebig Monument, at Munich, has been subscribed—the far greater part of the money coming, of course, from Germany. "England," says the *Lancet*, "numerous and deep as are her obligations to the father of agricultural chemistry, stands very low on the subscription-list, being, in fact, outstripped by Italy, which comes next, as a subscriber, to Germany itself."

A sandstone anvil has been discovered near Ironton, Ohio, supposed to have been used by the mound-builders. It is composed of very sharp grit, contains over 100 depressions, weighs about 500 pounds, and measures 8 feet 8 inches at its greatest circumference. This relic of an extinct race is to be presented to the Cincinnati Society of Natural History.

It may interest the consumers of Rhenish wines to learn that at Kehl there is a large establishment for the manufacture of wine without grapes. In the Rheingau and the Palatinate there are hundreds of similar establishments, according to the London *Times* correspondent. The Excise Bureau of the German Empire recognizes this product as grape-wine.

The English literary journals are discussing the question of forming one English word to represent what the French call a *savant*. "Man of science" is the only expression at present in approved usage that exactly corresponds to the French word. *Scientist* is "an American barbaric trisyllable." A writer in the *Academy* gives us our choice between "sciencist" and "scient."



PROFESSOR J. LAWRENCE SMITH.

THE

POPULAR SCIENCE MONTHLY.

DECEMBER, 1874.

THE PACES OF THE HORSE.[1]

IN the November MONTHLY we gave a brief account of Prof. Marey's method of representing the step of animals by means of graphic illustrations, with its application to human locomotion; we will now consider it as applied to the more complex paces of the horse. Hitherto, the locomotion of the horse has been mainly studied by means of the eye and ear. In the horse, even at a walk, the motions of the limbs are so confusing as to make it difficult for the untrained eye to follow them, and, when the pace is more rapid, the movements seem hopelessly intricate. Indeed, observation by the eye alone long since gave place to the use of the ear, which, taking account of the rhythm of the steps by the sounds they produce, afforded much more accurate results.

An expedient which greatly aided the observer, and which we shall find of service in explaining the results obtained by the graphic method, was to concentrate the attention on a single pair of limbs, instead of attempting to keep all four under observation at once. Any two limbs thus selected are called a *biped*, and this is designated according to the relative position of the limbs chosen. The horse may thus be parceled out into six different bipeds. The forward limbs constitute the *anterior biped;* the hind-limbs, the *posterior biped;* the two right limbs, the *right lateral biped;* the two left limbs, the *left lateral biped;* the right fore-leg and the left hind-leg, the *right diagonal biped;* the left fore-leg and the right hind-leg, the *left diagonal biped.* The horsey reader may dwell a moment upon this bit of equine technics, as it will materially assist him in understanding the explanation of the various paces.

The quadruped, when walking, has been compared to two men, placed one before the other, the hindmost following close upon the forward step of his companion. According as these persons (who ought both to take the same number of steps) move their limbs simultaneously, or alternately, according as the man in front executes his

[1] Abstract of Chapters IV., V., and VI., of "Animal Mechanism," by Prof. Marey. (Vol. XI. of "The International Scientific Series.")

movements more quickly or more slowly than the one behind, we see reproduced all the rhythms of the movements which characterize the different paces of the horse. Many have seen in the circus the figures of animals whose legs are formed by those of two men, with their bodies concealed in what represents the body of the quadruped. This grotesque imitation bears a striking resemblance to the animal when the movements of the two men are so well coördinated as to reproduce the rhythms of the paces.

Assuming the horse to be composed of two bipeds walking one be-

Fig. 1.—Notation of a Horse's Amble.

hind the other, let these, in progressing steadily, go through the same movements at the same time; that is, let the right leg of each be advanced at the same time and rate, the feet striking the ground so as to give but a single sound. While the body is resting on these, the left legs are simultaneously thrown forward, each striking the ground at the same moment, and so on alternately. The pace thus produced is known as the *amble*, and is the simplest of all the paces of the horse. The notation of its rhythms is given in Fig. 1. The upper line is derived from the movements of the *anterior*, or foremost biped; the

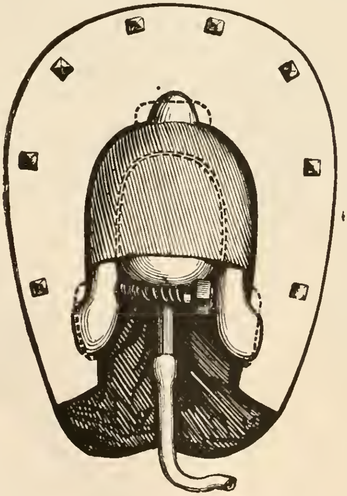


Fig. 2.—Experimental Apparatus to show the Pressure of the Horse's Hoof on the Ground.

lower, from the movements of the *posterior* or hindmost biped. The foot-falls of the right and left foot being produced at the same time by the biped walking in front, and by the one which follows, must be represented by similar signs placed exactly over each other. In the horse, this agreement between the movements of the fore and hind limbs belongs to the amble, and the notation is the same as would be given by that pace. In the amble, the ear perceives only two beats at each pace, the two limbs on the same side striking the ground at the same instant. In the notation, these two sounds are marked by vertical lines joining the two synchronous impacts. In the amble, the pressure of the body on the ground is said to be *lateral*, as the two limbs on one side only are in contact with the ground at the same time.

The rhythms of both the walk and the trot have been similarly ascertained and expressed, but beyond this the unaided senses have failed to give us much trustworthy information. It has been reserved for M. Marey to surmount the difficulties of the investigation; and we will now give, though necessarily in an imperfect way, some account of his methods and results.

For the shoe employed in the experiments on man, M. Marey substitutes, in the case of the horse, a ball of India-rubber filled with horse-hair, and attached to the shoe on the under-side of the hoof. The contrivance is shown in Fig. 2. A strong band of India-rubber passes over the apparatus and keeps in its place the ball filled with horse-hair, allowing it to rise slightly above the lower surface of the shoe. When the foot strikes the ground, the ball is compressed, which drives a part of the confined air into the registering instruments. As the foot is raised the ball recovers its form, and again fills with air, to be expelled at the next impact of the foot on the ground. Another form of apparatus, serving substantially the same purpose, and better adapted to ordinary roads, is seen in Fig. 3. This consists of a kind of leather bracelet fastened by straps to the leg of the horse just above the fetlock-joint. In front of this bracelet, which furnishes a solid point of resistance, is firmly fixed a flat box of India-rubber; this box communicates by a transmission-tube with the registering apparatus. Every pressure exerted on the box moves the corresponding registering-lever. A plate of copper,

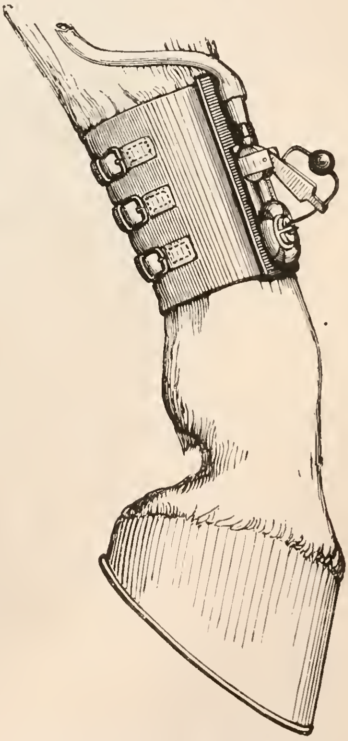


Fig. 3.—Apparatus to give the Signals of the Pressure and Rise of the Horse's Hoof.

inclined about 45°, is connected at its upper extremity with a kind of hinge, while its lower end is fastened by a heavy wire to the upper face of the India-rubber box, on which it presses by means of a flat disk. On a wire parallel to the slip of copper slides a ball of lead, the position of which can be varied so as to increase or diminish the pressure which this jointed apparatus exerts on the India-rubber box. This apparatus is called into action by the movements of the limb; the inclination of the oscillating portions allows them to act on the membrane constituting the wall of the box during the movement of elevation, of descent, and of horizontal progress of the foot.

The general arrangement of the apparatus, as it is applied to the horse, is seen in Fig. 4. Thick transmitting-tubes, not easily crushed, connect the experimental shoes, or instruments, on the legs, with the

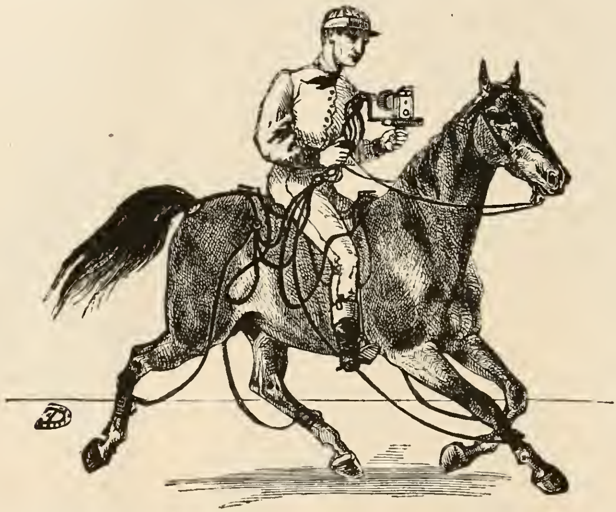


Fig. 4.—This Figure represents a Trotting-Horse, furnished with the Different Experimental Instruments; the horseman carrying the register of the pace.—On the withers and the croup are instruments to show the reactions.

registering apparatus in the hand of the rider. The registrar now carries a great number of levers; he must have four, at least, one for each of the legs, and usually two others, which receive their movements of reaction from the withers and the croup. The hand which holds the reins also carries a ball of India-rubber, which is connected by a tube with the registering instrument, and by means of which the tracings may be made to commence at any desired moment.

The tracings furnished by this apparatus, when the horse is at a full trot, and the notation of the rhythm of that pace, as derived from these tracings, are shown in Fig. 5. Above are the reactions taken from the withers for the fore-part of the animal, indicated by the line $R\ A$ (anterior reactions), and from the croup for the hinder part, indicated by the line $R\ P$ (posterior reactions). Below are given the curves of pressure of the four feet, drawn at two different levels: the uppermost are the curves of the anterior limbs; those below, of the posterior limbs. In each series the curves of the left foot are drawn with dotted lines, those of the right with full lines.

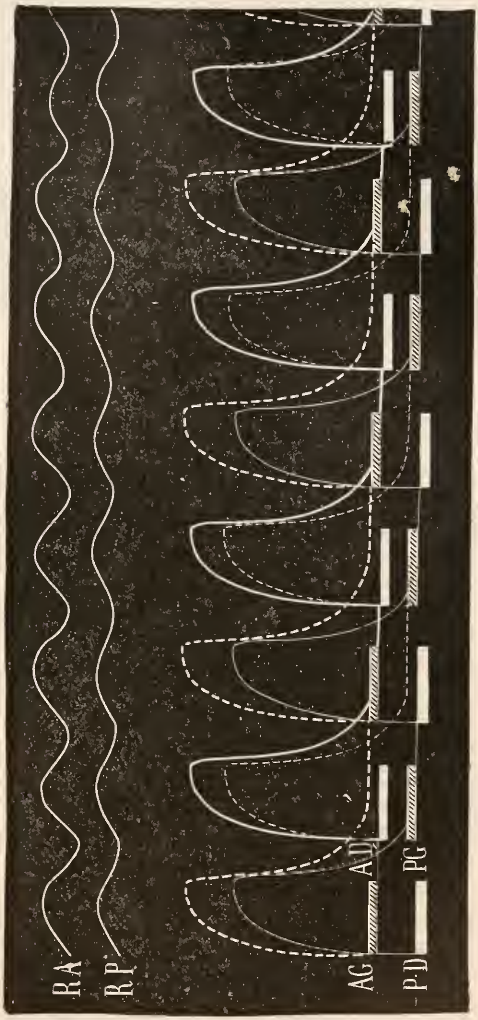


Fig. 5.—Graphic Curves and Notation of the Horse's Trot.—*R A*, reactions of the fore-limbs; *R P*, reactions of the hind-limbs; *A G* and *A D*, curves and notations of fore-limbs; *P D* and *P G*, curves and notations of hind-limbs.

The moment when the curve begins its rise represents the commencement of the pressure of the foot on the ground; the point at which the curve begins to descend represents the moment when the rise of the foot commences. It is seen from these tracings that the feet *A G* and *P D*, left fore-foot and right hind-foot, strike the ground at the same time. The simultaneous lowering of the curves of the two feet shows that they also rise from the ground simultaneously.

Under these curves is placed the notation which represents the pressure of the left diagonal biped. The second impact is given by the feet *A D* and *P G* (right diagonal biped), and so on through the whole length of the tracing. Thus the free trot is a pace in which all the four feet give but two strokes, and in which the ground is struck in turn by the two diagonal bipeds; it is also a *high pace*, the animal being raised for a brief interval between two successive strokes above the ground. The duration of this suspension, according to Fig. 5, is equal to half the time the feet are pressing on the ground. But the

Fig. 6.—Notation of the Irregular Trot.

trot varies greatly in different horses in this particular, there being oftentimes a very slight period of suspension, although a perfect synchronism of the diagonal strokes of the feet is observed.

By comparing the lines illustrating the reactions with the tracings afforded by the movements of the limbs, it will be seen that the mo-

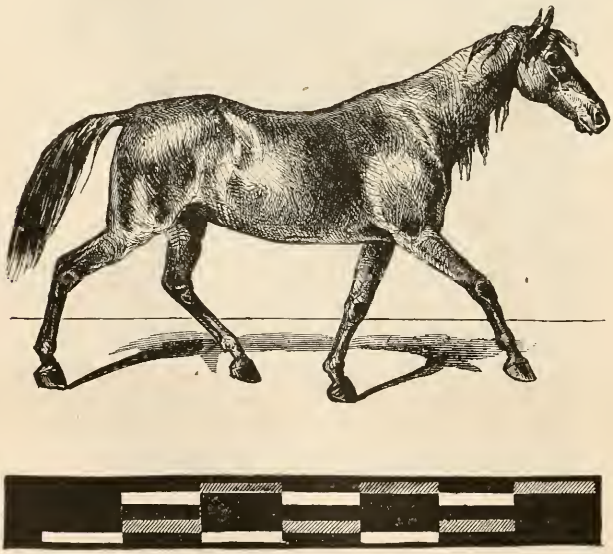


Fig. 7.—Horse trotting with a Low Kind of Pace.—The instant corresponding with the attitude represented in this figure is marked with a white dot on the notation.

ment when the body of the animal is at the lowest part of its vertical oscillation coincides precisely with that at which its feet touch the ground. The time of suspension does not depend on the fact that the body of the horse is projected into the air, but upon the fact that all four legs are bent during this short period. The maximum height of the suspension of the body corresponds, on the contrary, with the end of the pressure of the limbs on the ground. It is also seen that the reactions of the fore-limbs exceed those of the hind ones. This inequality appears to be constant, and is still more marked in the walking-pace.

We have learned that one of the chief characteristics of the free trot is the entire synchronism of the strokes of each diagonal biped. There is a form of this pace, however, called by M. Marey the *irregular trot*, where such synchronism is wanting, the hind limb of one or both diagonal bipeds striking the ground an instant later than the corresponding fore-limb. Fig. 6 represents the notation of the irregular trot. The stroke of the left fore-foot is seen to be a little earlier than that of the right hind-foot, and the same is true of the limbs belonging to the right diagonal biped.

The *low and short trot* is represented in Fig. 7. The diagonal impacts succeed each other without interval, as may be seen in the

FIG. 8.—HORSE AT FULL TROT.—The dot placed in the notation corresponds with the attitude represented.

notation placed below the figure. The animal has been depicted from the notation. The instant which the artist has chosen is that marked in the notation by a white dot. At this moment, as the superposition indicates, the left fore-foot is at the end of its pressure; the right fore-foot is about to reach the ground; the right hind-foot is finishing its pressure, and the left hind-foot is about to fall.

The *elevated and lengthened trot* is represented in Fig. 8. The animal is depicted at the instant which in the notation is represented by a dot; that is to say, during the time of the suspension, at the moment when the left diagonal biped has just risen, and the right diagonal biped is about to descend.

Tracings afforded by the walking-pace are shown in Fig. 9. If we let fall a perpendicular from the points at which the curves commence, we shall have the positions of the successive impacts of the four legs. The order of succession of impacts is represented by the letters *A D*, *P G*, *A G*, *P D*, that is to say, *right fore-foot*, *left hind-foot*, *left fore-foot*, *right hind-foot*. The notation of the rhythm of the pressure of each foot, as derived from the registered curves, shows that the interval which separates the impacts is the same throughout, and consequently that the horse rests during the same time on the lateral as on the diagonal bipeds. This, however, is not always the case, some horses resting longer on the lateral biped than on the diagonal, and *vice versa*. The change of position of the centre of gravity may be seen by reference to Fig. 9. From 1 to 2 the horse will rest on the right lateral biped; from 2 to 3 on the right diagonal biped (that is to say, on that in which the *right* foot comes first); from 3 to 4 on the left lateral biped; from 4 to 5 on the left diagonal biped; again, from 5 to 6 the horse would find himself, as at the beginning, on the right lateral biped.

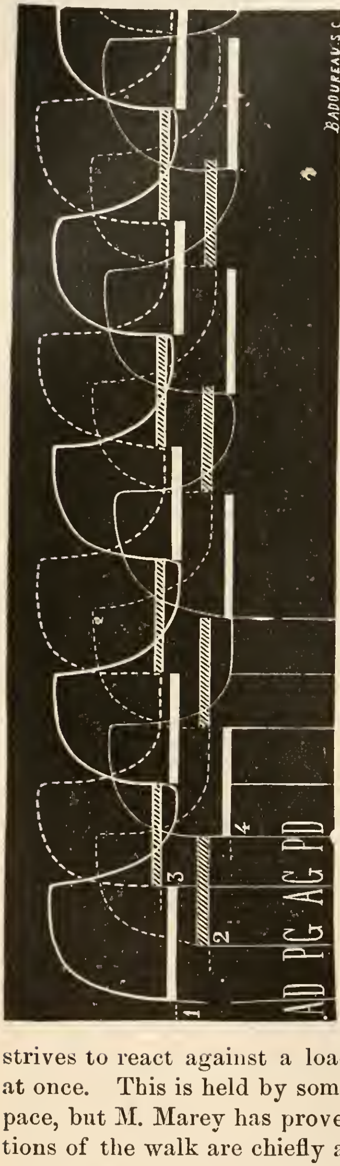


Fig. 9.—Tracings and Notations of the Walking-Pace, with Equal Pressures of the Feet, both Diagonally and Laterally.

Observations on draught-horses have shown that, when the animal strives to react against a load, he may have three feet on the ground at once. This is held by some to be the rule in the normal walking-pace, but M. Marey has proved to the contrary. The vertical oscillations of the walk are chiefly at the withers, those of the croup being very slight. The actions of the hinder parts seem to consist chiefly in a forward propulsion, with a scarcely perceptible impulsion of the body in an upward direction. This agrees with the theory quite generally admitted, that the fore-legs have little to do in the normal pace, except to support alternately the fore-part of the body, while to the hind-limbs belong the propulsive action and the tractive force exerted by the animal. Fig. 12 is a representation of the horse at a walking-pace. The instant is marked in the notation by a dot.

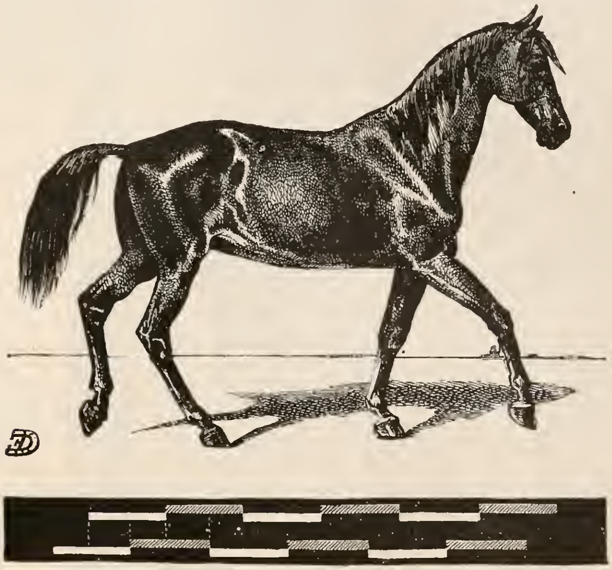


FIG. 10.—REPRESENTATION OF THE HORSE AT A WALKING-PACE.

The gallop comprises all those paces in which irregular impacts of the feet upon the ground recur at regular intervals. Most writers distinguish three kinds of gallop by the rhythm of the impacts, and name them, according to this rhythm, gallop in *two*, three, and four time. The most common kind is the gallop in three-time, from which the tracings in Fig. 11 have been obtained. At the commencement of the figure the animal is suspended above the ground; then comes the impact *P G*, which announces that the left hind-foot touches the ground. This is the foot diagonally opposed to that which the horse places forward in the gallop, and whose impact *A D* will be the last produced. Between these two impacts and in the middle of the interval which separates them, comes the simultaneous impact of the two feet forming the left diagonal biped. The superposition of the notations *A G*, *P D*, clearly shows this synchronism. In this series of movements the ear has therefore distinguished *three* sounds at nearly equal intervals. The first sound is produced by a hinder-foot, the second by a diagonal biped, the third by a fore-foot. Between the single impact of a fore-foot, which constitutes the third sound, and the first beat of the pace which follows, there is a period of silence whose duration is exactly equal to that of the three impacts taken together; then the series of movements recommences.

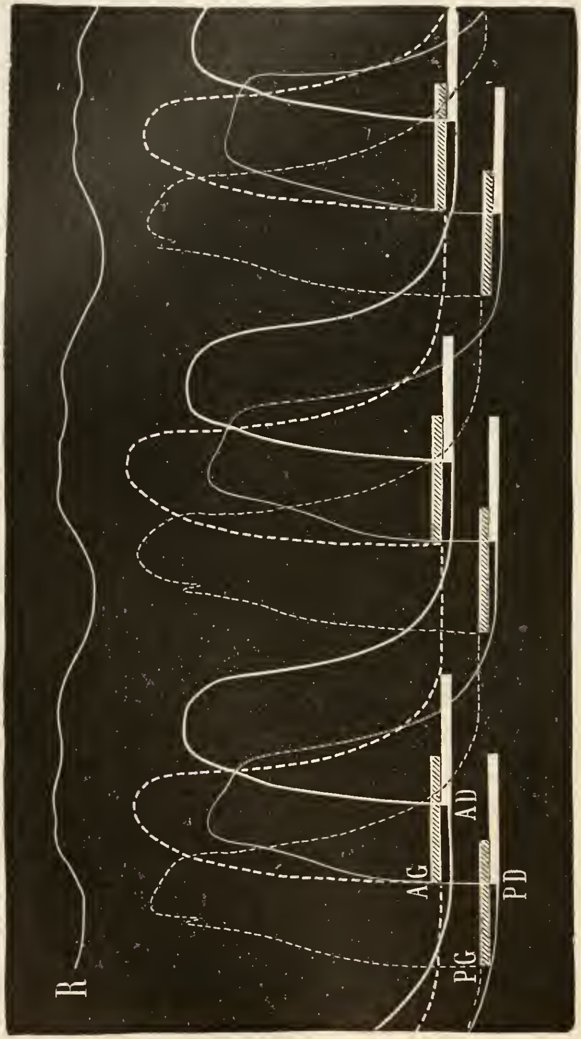


Fig. 11.—Tracings and Notation of the Gallop in Three-time.—*R*, curve of reactions taken at the withers. The curves of the reactions of the feet have a considerable extent, which shows the force of the pressures on the ground. The horse used for this experiment galloped with the right foot, as seen in the notation.

By an inspection of the curves, we see that the pressure of the feet on the ground must be more energetic in the gallop than in the paces already described, the height of the curves being greater than for either the trot or the walk. The greatest energy seems to belong to the first impact. At this moment, the body, raised for an instant from the ground, falls again, and one leg alone sustains the shock.

The notation, Fig. 12, enables us to follow (in *A*) the succession of impacts; and shows (in *B*) the succession of the limbs which cause these pressures on the ground. The reactions of this pace, produced at the withers, are seen in Fig. 11 (*R*). There is an undulatory elevation, which lasts all the time that the animal touches the ground; in

FIG. 12.—GALLOP IN THREE-TIME.—*A*, indication of three time; *B*, indication of the number of feet which form the support of the body at each instant of the gallop in three-time.

this elevation are recognized the effects of the three impacts, which give it a triple undulation. The minimum elevation of the curve corresponds, as in the trot, with the moment when the feet do not touch the ground. Therefore, it is not a projection of the body into the air,

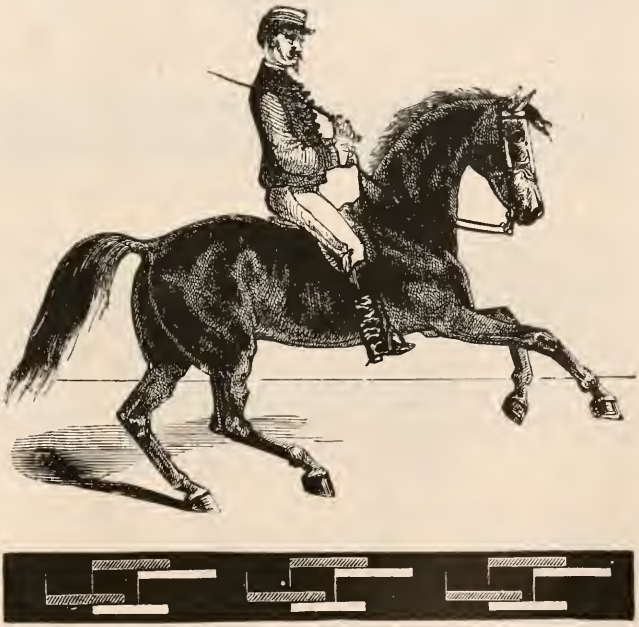


FIG. 13.—HORSE GALLOPING IN THE FIRST TIME (RIGHT FOOT ADVANCING), THE HIND LEFT FOOT ONLY ON THE GROUND.—The white dot, in the notation, corresponds with the instant at which the horse is represented.

which constitutes the time of suspension of the gallop. By comparing the reactions of this pace with those of the trot (Fig. 5), we see that in the gallop the rise and fall of the body are effected in a less sudden manner. These reactions are, therefore, less jarring to the rider, though they may, in fact, present a greater amplitude.

The attitude of the horse at the moment of the first beat of the gallop in three-time is given in Fig. 13. The left hind-foot, on which the horse has just descended, alone rests on the ground.

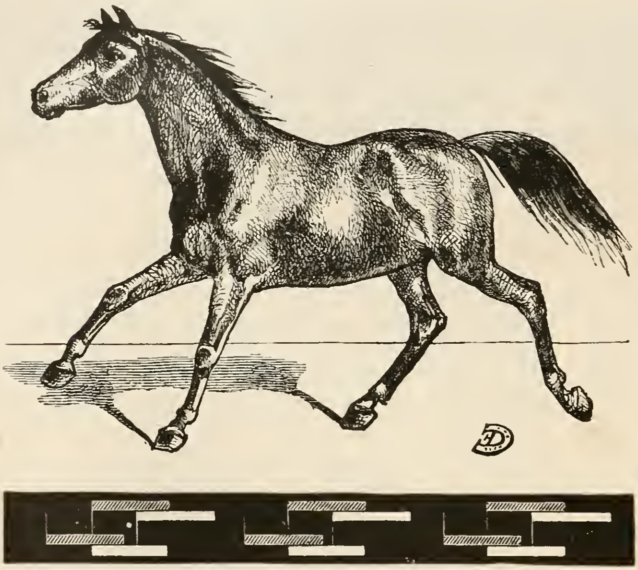


Fig. 14.—Horse galloping in the Second Time (Right Foot forward).

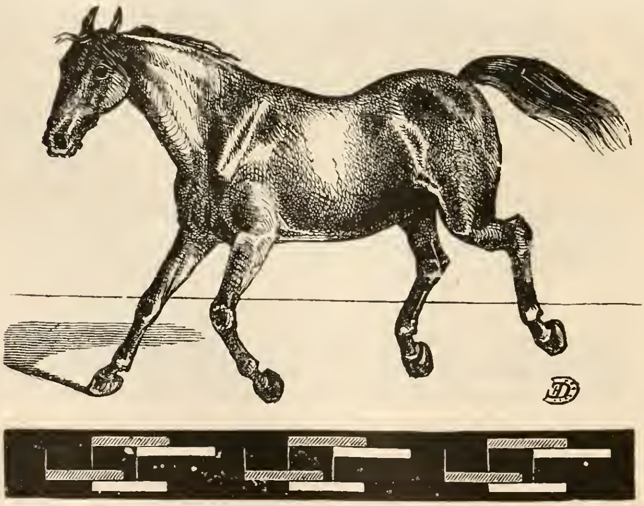


Fig. 15.—Horse galloping in the Third Time (Right Foot forward).

Fig. 14 is the position of the horse at the time of the second beat, or at the moment when the left diagonal biped has finished its impact;

the right fore-foot is about to reach the ground, the left hind-foot has just risen.

At the third or last beat of the pace, the position of the animal is that given in Fig. 15. The moment chosen is that in which the right foot alone rests on the ground, and is about to rise in its turn.

The gallop in four-time differs from that which has just been described only in this particular, that the impacts of the diagonal biped, which constitute the second beat of that gallop, are in this case disunited and give distinct sounds. This is shown in Fig. 16. According to this notation, the body, at first suspended, is borne successively on one foot, on three, on two, on three, and on one, after which a new suspension commences.

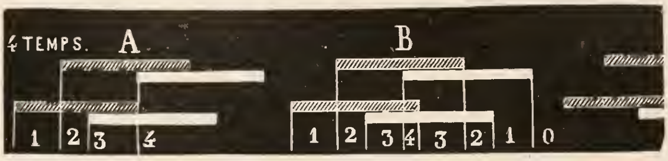


Fig. 16.—Notation of the Gallop in Four-time.—*A*, determination of each of the successive times; *B*, determination of the number of feet which support the body at each instant.

The full gallop, which is a very rapid pace, is in four-time. The impacts of the hinder-limbs, however, follow each other at such short intervals, that the ear can only distinguish one of them; but those of the fore-legs are notably more separated, and can be heard distinctly as two sounds. The notation of the full gallop (Fig. 17) confirms this. Another character of the full gallop is, that the longest period of silence takes place during the pressure of the hinder-limbs. The time of suspension appears to be extremely short. The reactions in the full gallop reproduce with great exactness the rhythm of the impacts. Thus it is observed that, at the moment of the almost synchronous impacts of the two hinder limbs, there is a sharp and prolonged reaction, after which two less sudden reactions take place, each of which corresponds with the impact of one of the fore-feet. The irregular line in Fig. 17 is the tracing of the reactions at the withers.

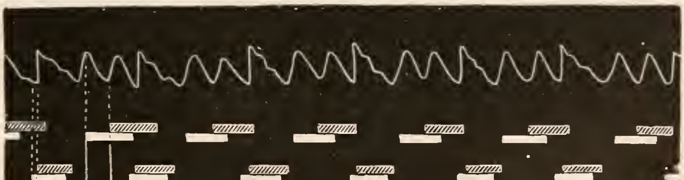


Fig. 17—Notation of Full Gallop; Reactions of this Pace.

Many other points relating to the locomotion of the horse, such as the characters of the footprints belonging to each pace; the transition from one pace to another; the modification of the movements incident to pulling a load, etc., we are unable to notice here, and would therefore refer the interested reader to M. Marey's work, where he will find the subject fully elucidated.

ODORS AND LIFE.

BY FERNAND PAPILLON.

TRANSLATED FROM THE MONITEUR SCIENTIFIQUE, BY A. R. MACDONOUGH.

DESCARTES, Leibnitz, and all the great minds of the seventeenth century, believed that phenomena are such interdependent parts of one whole, that they require to be explained by each other, and consequently, that a very close mutual connection should be maintained among the sciences. In their view, this was the condition of rapid advance and intelligent development. The experimental method, constant to systematic obstinacy in erecting so many barriers between the different sections of natural philosophy, has greatly hindered the completeness of whatever knowledge we possess as the result of mutual interaction among all truths. At this day, such barriers are tending to vanish of their own accord, and the science of man in his relations with external media begins to show the outlines of its plan and harmony. We have before this sketched several of its chapters, and we will endeavor now to write another, on the subject of odors.

I.

The seat of smell, or the olfactory sense, is the pituitary membrane lining the inner wall of the nostrils. It is a mucous surface, laid in irregular wrinkles, and receiving the spreading, slender, terminal filaments of a certain number of nerves. This membrane, like all other mucous ones, constantly secretes a fluid designed to lubricate it. By the aid of the muscles covering the lower part of the nostrils, the apparatus of smelling can be dilated or contracted, precisely like that of sight. This understood, the mechanism of olfaction is quite simple. It consists in the contact of odorous particles with the olfactory nerve. These particles are conveyed by the air to the inside of the nasal cavities, and there strike upon the sensitive fibres. If the access of air is prevented, or if the nerve is altered, no sensation is produced. Experiments in physiology, in fact, have settled that the olfactory nerves (or those of the first pair) are assigned exclusively to the perception of odors. Loss of the sense of smell occurs whenever the nerves are destroyed or injured by any process, or even whenever they are merely compressed. On the other hand, it is a matter of common observation that impeding the passage of air into the nostrils is quite as effectual a way of making any sort of olfactory sensation impossible. Let us add, that the region most sensitive to odors is that of the upper part of the nasal cavities. There are, as we shall notice in proceeding, considerable differences as regards the degree of sensitiveness in this sense of smell, comparing one man with another. But it is a still more singular fact that sometimes, without apparent cause, the sense is utterly wanting. In other cases it is unaffected by the action of certain odors only, an analogous infirmity to that which students of the eye call *daltonism*, and which consists in the perception of certain colors only. We find in scientific annals the case of a priest who was insensible to all odors except that of a manure-heap, or that of decayed cabbage; and another, of a person to whom vanilla was entirely without scent. Blumenbach speaks too of an Englishman, with all his senses very acute, who perceived no perfume in mignonette.

Olfaction is sometimes voluntary, sometimes involuntary. In the former case, by an act which is called scenting something, and is resorted to for the sake of a keener sensation, we first close the mouth, and then sometimes draw in a full breath, sometimes a succession of short, quick inspirations. Then the muscular apparatus edging the opening of the nostrils comes into play, to contract that orifice, and point it downward, so as to increase the intensity of the current of inhaled air. When, on the contrary, we wish to smell as little as possible, the organ becomes passive. We effect strong expirations by the nose to drive out the air that produces scent, and inhalation, instead of being performed by the nostrils, instinctively takes place through the mouth.

Scents and the sense of smell have an important share in the phenomena of gustation, that is, there is a close connection between the perception of odors and that of tastes. Physiological analysis has clearly brought out the fact that most of the tastes we perceive proceed from the combination of olfactory sensations with a small number of gustatory sensations. In reality, there are but four primitive and radical tastes—sweet, sour, salt, and bitter. A very simple experiment will convince us of this fact. If we keep the nostrils closed when tasting a certain number of sapid substances, so as to neutralize the sense of smell, the taste perceived is invariably reduced to one of the four simple savors we have just named. Then, whenever the pituitary membrane is out of order, the taste of food is no longer the same; the tongue distinguishes nothing but sweet, sour, salt, or bitter.

It is time now to begin the study of the physiological and chemical conditions of smell, and for this we must first inquire how odorous substances behave with regard to the medium which separates them from our organs. Prévost, in an essay published in 1799 on the means of making emanations from odorous bodies perceptible to sight, was the first to bring to view the fact that certain odorous substances, solid or fluid, placed on moistened glass, or in a saucerful of water, instantly act on those molecules of the liquid which they touch, and repel them more or less, producing a vacuum. He judged that this method might serve to make odors sensible to sight, and enable us to distinguish odorous from inodorous bodies. These movements of odorous bodies on the surfaces of liquids, of which camphor particularly gives so curious an instance, have lately been studied with the greatest care by a French physiologist, with a view to establishing a theory of odors. With this purpose Liégeois has examined most of the odoriferous substances, and has ascertained that almost all of them perform various motions of circulation and displacement on the surface of water, resembling those noted with camphor. Some act precisely as camphor does. Among these are benzoic acid, succinic acid, the rind of bitter oranges, etc. With others, motion soon stops, for they are quickly surrounded by an oily film which keeps them confined. Some must be reduced to powder before the phenomenon takes place. As regards odorous liquids, it occurred to Liégeois to saturate very light and spongy seeds, themselves odorless, with them, and he then found, on throwing the seeds on water, that circulatory and displacing movements took place, as with other substances. He concluded, from a series of experiments methodically tried, that the motions in question must be attributed, not to a release of gas, acting in the manner of a recoil, but simply to the separation and rapid diffusion, within the water, of the odorous particles. The volatility of substances cannot be admitted to have any part in explaining the phenomenon. It depends wholly on the affinity of fluids for the odorous particles, and also for those of fatty matter. Liégeois found, for instance, that a drop of oil put on the surface of water, without sensibly lessening in size, emits an enormous quantity of microscopic droplets, which are diffused through the mass of the water. Aromatic essences produce a like effect. Though insoluble in water, they have a powerful tendency to disperse themselves throughout it, and water that receives a very small quantity of the odoriferous principle, in the shape of extremely fine powder, has enough to gain their perfume completely. Liégeois's experiments give proof of the most diligent labors and of praiseworthy sagacity. Science has accepted them with satisfaction, and, after employing them usefully, will preserve the memory of their author, taken away in the flower of his age, at the outset of a noble career as a physiologist and surgeon.

It seemed, to quote his words, as though in these experiments we were assisting at the formation of the odorous molecules. Those delicate atoms emitted from odorous substances and diffused through the atmosphere are, in fact, the very same that impinge on our pituitary membrane, and give us the sensation of odors. Moreover, facts long ago observed display this revealing action, so to call it, of water upon odors. At morning, when the verdure is moist and the flowers covered with sparkling pearls of dew, a fresher and balmier fragrance exhales from every plant. It is the same after a light shower. Vegetation gains heightened tints, at the same time that it diffuses more fragrant waves of perfume. We remark an effect of the same kind in the physiological phenomenon of taste. The saliva serves as an excellent vehicle for diffusing the odorous principles; then the movements of the tongue, spreading that fluid over the whole extent of the cavity of the mouth, and thus enlarging the evaporating surface, are clearly of a kind to aid the dispersion of the odorous principles, which, as we have seen, take a considerable part in the perception of tastes.

Now, in the phenomenon of smell, air acts in the place of water. It seizes the odorous particles and brings them into contact with the pituitary membrane. It is the vehicle, the solvent, of those extremely subtile atoms which, acting on the delicate fibres of the nerve, produce in it a special movement, which translates itself into the most varied sensations. Oxygen, and the existence in that gas of a certain proportion of odorous molecules, are the two essential conditions of this phenomenon.

Such is, at least, the result of earlier experiments, and of those performed of late years by Nicklès. A curious fact, well worthy of attention, is the remarkable diffusibility and degree of subdivision exhibited by some odorous substances. Ambergris just thrown up on the shore spreads a fragrance to a great distance, which guides the seekers after that precious substance. Springs of petroleum-oil are scented at a very considerable distance. Bartholin affirms that the odor of rosemary at sea renders the shores of Spain distinguishable long before they are in sight. So, too, every one knows that a single grain of musk perfumes a room for a whole year, without sensibly losing weight. Haller relates that he has kept papers for forty years perfumed by a grain of amber, and that they still retained the fragrance at the end of that time. He remarks that every inch of their surface had been impregnated by $\frac{1}{26910064000}$ of one grain of amber, and that they had perfumed for 11,600 days a film of air at least a foot in thickness. Evidently the material quantity of the odorous principle contained in a given volume of such air is so minute as to elude imagination. We can readily conceive how philosophers cite such instances to give a notion of the divisibility of matter.

In fact, we are now considering matter emitted by odorous bodies. This shows that they do not act as centres of agitation, occasioning vibrations which pass in waves to our organs, to exert on them a purely dynamic influence. This giving off of odorous matter, with the necessary aid of oxygen in the atmosphere, proves, too, that odors are in no respect comparable to light or heat, which one may regard in an abstract way, in the immaterial and ethereal space which is the region of their motion, as proper forces, and acting from a distance. Odors, to be perceived, must be taken up by oxygen, and borne by it to the organ of smell. In a word, odor is the odoriferous particle itself, while light is not the light-giving body.

Does oxygen exert a chemical influence on those atoms of which it robs odorous substances? We do not know, neither do we know of what kind is the action which occurs on the contact of odor with the olfactory nerve, whether the phenomenon is a mere mechanical agitation, or whether some chemical decomposition takes place in the case. At any rate, it is allowable to reason from the observed facts that smell and taste are two senses peculiarly distinct from the others, as well with respect to the object of sensation as to the ideas which the mind derives from the sensation itself. Sight, touch, and hearing, in a manner physical senses, furnish us the ideas of external forms, harmonies, and motions. They introduce us to the conception of the beautiful, and are true fellow-laborers with the intellect. Taste and smell are rather chemic senses, as Nicklès calls them. They come into action only upon contact, and awake in us only such sensations as life and mind gain no profit from. While the former are the spring of the highest functions, the latter are of use only for the performance of acts of nutrition.

The learned and capable author[1] of a book on odors, published within a few years, fancies, however, that he can establish a kind of æsthetics of odors, more or less resembling that of tones. He has investigated olfactory harmonies, hoping to find in them the elements of a sort of music. "Odors," he says, "seem to affect the olfactory nerves in certain definite degrees, as sounds act on the auditory nerves. There is, so to speak, an octave of smells, as there is an octave of tones; some perfumes accord, like the notes of an instrument. Thus almond, vanilla, heliotrope, and clematis, harmonize perfectly, each of them producing almost the same impression in a different degree. On the other hand, we have citron, lemon, orange peel, and verbena, forming a similarly associated octave of odors, in a higher key. The analogy is completed by those odors which we call half-scents, such as the rose, with rose-geranium for its semitone; 'petit-grain' and neroli, followed by orange-flower. With the aid of flowers already known, by mixing them in fixed proportions, we can obtain the perfume of almost all flowers." In accordance with these fancies, Piesse has formed gamuts of odors, parallel with musical gamuts, and exhibiting concords of scents at the same time with those that produce discords. As a painter blends his tints, the perfumer should blend his fragrances; and Piesse maintains he can only gain that object by following the laws of harmony and contrast in odors. This theory is certainly quite ingenious, and deserves attention, but it is open to serious objections. If the harmony of colors and of sounds exists, it is because optics and acoustics are exact sciences, and harmony in this case is reduced to numerical relations,

[1] Piesse, on "Odors, Perfumes, and Cosmetics."

determined in a positive way. These relations, as concerns odors, can have no other basis than a capricious and relative sensibility. They are thus incapable of being reduced to form, *a fortiori* of being translated into fixed precepts.

To complete these details, it remains to say something of the delusions of the sense of smell; for this sense, like the others, has its aberrations and hallucinations. The delusions of smell are hardly ever isolated; they accompany those of hearing, sight, taste, and touch, and are also less frequent than the latter. Insane people, who are affected by them, complain of being haunted by fetid emanations, or congratulate themselves on inhaling the most delicious perfumes. Lelut mentions the case of a woman, an inmate of la Salpêtrière, who fancied that she constantly perceived a frightful stench proceeding from the decay of bodies she imagined buried in the courts of that institution. Impressions of the kind are usually very annoying. Brierre de Boismont relates the account of a woman affected by disorder of all her senses. Whenever she saw a well-dressed lady passing, she smelt the odor of musk, which was intolerable to her. If it were a man, she was distressingly affected by the smell of tobacco, though she was quite aware that those scents existed only in her imagination. Capellini mentions that a woman, who declared that she could not bear the smell of a rose, was quite ill when one of her friends came in wearing one, though the unlucky flower was only artificial.

Such facts might be multiplied; but, as they are all alike, it is not worth while to mention more of them. The latest observations made in insane asylums, among others, those of M. Prévost, at la Salpêtrière, have shown also that these delusions and perversions of the sense of smell are more common than had hitherto been supposed among such invalids, and that if they usually pass unnoticed, it arises from the fact that nothing spontaneously denotes their existence.

The intensity and delicacy of the sense of smell vary in mankind among different individuals, and particularly among different races of men. While some persons are almost devoid of the sense of smell, others, whose history is related in the annals of science, have displayed a refinement and range in the distinction of odors truly wonderful. Woodward, for instance, mentions a woman who foretold storms several hours before their coming, by the help of the sulphurous odor, due probably to ozone, which she perceived in the atmosphere. The scientific journals of the day relate the account of a young American girl, a deaf-mute, who, by their odor alone, recognized the plants of the fields which she collected. Numerous instances, moreover, prove that in savage races this sense is very greatly more developed than among civilized men. It is a traveler's story, that some tribes of Indians can pursue their enemies and animals of the chase by mere scent.

But it is among the other mammals that we find the sense of smell displayed in its highest degree of power and perfection. Among ruminants, some pachyderms, and particularly among carnivorous mammals, the olfactory membrane attains the keenest sensitiveness. Buffon has described these animals with extreme exactness, in saying that they smell farther than they see, and that they possess in their scent an eye which sees objects not only where they are, but even wherever they have been. The peculiarity of scent in the dog is too well known to need more than an allusion.

If we can hardly give faith to those ancient historians who relate that vultures were attracted from Asia to the fields of Pharsalia by the smell of the corpses heaped together there after a famous battle, yet we must accept the assertions of naturalists so well qualified to observe as, for instance, Alexander von Humboldt. The latter relates that in Peru, and other countries of South America, when it is intended to take condors, a horse or cow is killed, and that in a short time the smell of the dead animal attracts a great number of these birds, though none had before that been seen in the country. Other more extraordinary facts are told by travelers. These must usually be received only with the greatest caution, because in most cases the sense of smell gains credit for what is due to the sense of sight, which, with these birds, is very keen and far-reaching. Yet, making allowance for exaggeration, it must be admitted that these animals have a very highly-developed sense of smell. Scarpa, who has made admirable researches on this subject, found that they refuse food which is saturated with odorous substances, and, as an odd instance, that a duck would not swallow perfumed bread till after it had washed it in a pond. The waders, which have the largest olfactory nerves, are also those birds that display the greatest keenness of scent. Reptiles have very large olfactory lobes, leading us to believe that they discern odors readily, but at present we know little of the impressions they are sensitive to in this respect. Fish also have an olfactory membrane. Fishermen have always remarked that they may be attracted or driven off by throwing certain odorous substances into the water. Sharks, and other voracious fish, collect in crowds and follow from very far about a body thrown into the sea. It is even said that, when blacks and whites are bathing together in latitudes where these fish abound, they particularly single out and pursue the more strongly odorous blacks. Nor are the crustacea indifferent to emanations which act on the olfactory nerve. The method used for attracting and taking crabs is familiar.

Regarding the lower animals we have only still more uncertain information, except as to insects. Entomologists maintain that scent is very delicate in most insects, and rely on plausible conjectures on this subject, but they do not as yet know what the seat of the sense of smell in insects is. When meat is exposed to the air, in a few moments flies make their appearance in a place where none had before been seen. If refuse matter or bodies of animals are left on the ground, insects flock to them at once, feeding on such substances, and depositing their eggs in them. Scent alone seems to guide them, exclusively of sight even, for, if the object of their desire is hidden, they easily manage to find it. A curious fact as to the scent of insects is furnished by those kinds that prefer decaying substances. A beautiful arum is found in our woods, the cuckoo-pintle, whose white flower diffuses a disgusting odor. Now, the inside of this flower is often filled with flies, snails, and plant-lice, seeking the putrid source of this fetid smell. We may see the little creatures, in quest of their food or of a fit place to lay their eggs, move about in all directions, and quit most unwillingly the flower whose scent has misled them.

II.

Having thus learned what physiologists think of the sense of smell and the conditions of the perception of odors, let us see what naturalists and chemists have ascertained respecting the latter as viewed in themselves, what place they give to odorous bodies, and what character they attribute to them all. The three kingdoms possess odors. Among mineral substances, few solids, but quite a number of liquids and gases, are endowed with more or less powerful scents, in most cases not very pleasant ones, and usually characteristic. Those odors belong to simple substances, such as chlorine, bromine, and iodine; to acids, as hydrochloric and hydrocyanic acid; to carburets of hydrogen, as those of petroleum; to alkaline substances, ammonia, for instance, etc. The odors observable among minerals may almost all be referred either to hydrocarbonic or hydrosulphuric gases, or to various solid and liquid acids produced by the decomposition of fats, or to peculiar principles secreted by glands, such as musk, ambergris, civet, and the like. Vegetables present quite another variety of odors, from the faintest to the rankest, from the most delicious to the most disgusting. Absolutely scentless plants are very rare, and many, that seem to be so while they are fresh, gain, on drying, a very decided perfume.

The odor of plants is due to principles very unequally distributed throughout their different organs; some solid, as resins and balsams, others which are liquid, and known by the name of essences or essential oils. In most cases the essence is concentrated in the flower, as occurs with the rose and the violet. In other plants, as in bent-grass and Florence iris, only the root is fragrant. In cedar and sandal wood, it is the wood that is so; in mint and patchouli, the leaves; in the Tonquin bean, the seed; in cinnamon, the bark, which is the seat of the odorous principle. Some plants have several quite distinct fragrances. Thus the orange has three: that of the leaves and fruit, which gives the essence known by the name of "petit-grain;" that of the flowers, which furnishes neroli; and again the rind of the fruit, from which essence of Portugal is extracted. A great number of vegetable odors belong exclusively to tropical plants, but the flora of Europe furnishes a large proportion of them, and almost all the essences used in perfumery are of European origin. England cultivates lavender and peppermint largely. At Nîmes, gardeners are particularly attentive to rosemary, thyme, petit-grain, and lavender. Nice has the violet for its speciality. Cannes extracts all the essences of the rose, the tuberose, cassia (the yellow acacia), jasmine, and neroli. Sicily produces lemon and orange; Italy, bergamot and the iris.

What, now, is the chemical nature of the odorous principles in plants? The chemistry of to-day reduces almost all of them to three categories of well-ascertained substances: hydrocarburets, aldehydes, and ethers. We will endeavor to give a clear account of the constitution of these three kinds of substances, and to mark their place in the register of science. The hydrocarburets are simple combinations of carbon and hydrogen, as, for instance, the petroleum-oils. They represent the simple compounds of organic chemistry. As to aldehydes and ethers, their composition is rather more complex; besides carbon and hydrogen, they contain oxygen. Every one knows what chemists mean by an alcohol; it is a definite combination of hydrogen, carbon, and oxygen, neither acid nor alkaline, which may be regarded as the result of the union of a hydrocarburet with the elements of water. Common alcohol, or spirits of wine, is the type of the most important series of alcohols, that of the mono-atomic alcohols. Chemists represent it by the formula C^2H^6O, to indicate that a molecule of it arises from the union of two atoms of carbon with six atoms of hydrogen and one of oxygen. Independently of the alcohols, which are of great number and varying complexity, organic chemistry recognizes another class of bodies, of which vinegar is the type, and which receive the name of organic acids, to mark their resemblance to mineral acids, such as oil of vitriol or aqua-fortis. Now, every alcohol, on losing a certain amount of hydrogen, gives rise to a new body, which is called an aldehyde; and every alcohol, on combining with an acid, produces what is called an ether. These rapid details allow us to understand precisely the chemical character of the essences or essential oils which plants elaborate within their delicate tissue. Except a small number among them which contain sulphur, as the essences of the family of crucifers, they all present the same qualitative composition—carbon and hydrogen, with or without oxygen. Between one and another of them merely the proportion of these three composing elements varies, by regular gradations, but so as always to correspond either to a hydrocarburet, or to an aldehyde, or to an ether. In this case, as in almost the whole of organic chemistry, every thing is in the quantity of the composing elements. The quality is of so little importance to Nature, that, while following always the same laws, and constantly using the same materials, she can, by merely changing the ponderable relations of the latter, produce, by myriads of various combinations, myriads of substances which have no resemblance to each other. The strange powers of the elements and the mysterious forces concealed in matter make themselves known to us in a still more remarkable phenomenon, to which the name of *isomery* is given. Two bodies, thoroughly unlike as regards their properties, may present absolutely the same chemical composition with respect to quality and quantity of elements. "But in what do they differ?" it may be asked. They differ in the arrangement of their molecules. Coal and the diamond are identical in substance. Common phosphorus and amorphous phosphorus are one and the same in substance. Now, the odorous principles of plants offer some exceedingly curious cases of isomery. Thus the essence of turpentine, the essence of lemon, that of bergamot, of neroli, of juniper, of savin, of lavender, of cubebs, of pepper, and of gillyflower, are isomeric bodies, that is, they all have the same chemical composition. Subjected to analysis, all these products yield identical substances in identical proportions, that is, for each molecule of essence, ten atoms of carbon, and sixteen atoms of oxygen, as denoted by their common formula, $C^{10}O^{16}$. We see how these facts as to isomery prove that the qualities of bodies depend far more on the arrangement and the inner movements of their minute particles, never to be reached by our search, than on the nature of their matter itself; and they show, too, how far we still are from having penetrated to the first conditions of the action and forces of substances. Among odoriferous essences placed by chemists in the class of aldehydes may be named those of mint, rue, bitter almonds, anise, cummin, fennel, cinnamon, etc. The rest are ranged in the great series of ethers, which vary greatly in complexity, notwithstanding the simple uniformity of their primary elements.

Such is the chemical nature of most of the odorous principles of vegetable origin. But chemistry has not stopped short with ascertaining the inmost composition of these substances; it has succeeded in reproducing quite a number of them artificially, and the compounds thus manufactured, wholly from elements, in laboratories, are absolutely identical with the products extracted from plants. The speculations of theory on the arrangements of atoms, sometimes condemned as useless, do not merely aid in giving us a clearer comprehension of natural laws, which is something of itself, but they do more, as real instances prove; they often give us the key to brilliant and valuable inventions. An Italian chemist, who was then employed in Paris, Piria, in 1838, was the first who imitated by art a natural aromatic principle. By means of reactions suggested by theory, he prepared a salicilic aldehyde, which turned out to be the essence of meadow-sweet, so delicate and subtile in its odor. A few years later, in 1843, Cahours discovered methylsalicilic ether, and showed that it is identical with the essence of wintergreen. A year after, Wertheim composed essence of mustard, while believing himself to be making only allylsulphocyanic ether. These discoveries produced a sensation. Nowadays the chemist possesses the means of creating many other natural essences. Common camphor, essence of bitter-almonds, that of cummin and of cinnamon, which are aldehydes, as we have seen, may be prepared without camphor-leaves or almonds, without cummin or cinnamon. Besides these ethers and aldehydes whose identity with essences of vegetable origin has been proved, there exist, among the new bodies known to organic chemistry, a certain number of products formed by the union of common alcohol or amylic alcohol with different acids, that is to say, of ethers, which have aromatic odors more or less resembling those of some fruits, but as to which it cannot yet be affirmed that the odors are due to the same principles in both cases. However this may be, perfumers and confectioners, more industrious and wide-awake than chemists, have immediately made good use of these properties. Artificial aromatic oils made their first appearance at the World's Fair of London in 1851. There was there exhibited a pear-oil, diffusing a pleasant smell like that of a jargonel, and employed to give an aroma to bonbons. This product is nothing else than a solution of amylacetic ether in alcohol. Apple-oil was exhibited beside the pear-oil, having the fragrance of the best rennets, and produced by dissolving amylvaleric ether in alcohol. The commonest essence was that of pineapple, which is nothing else than ordinary butyric ether. There was observed, too, an essence of cognac, or grape-oil, used to impart to poor brandies the highly-prized aroma of cognac. The product which was then, and still is, the most important article of manufacture, is the essence of "mirbane," which very closely resembles in its odor that of bitter almonds, and which commerce very often substitutes for the latter. Essence of mirbane is nothing else than nitrobenzine, which results from the action of nitric acid on benzine. Benzine, in turn, is met with among the products of distillation of tar, which also yield the substances used in preparing those beautiful colors called aniline. Besides the essences we have just mentioned, which are gaining an increasing importance in the manufacturing arts, artificial essences of quinces are also prepared, and essences of strawberries, of rum, etc. All these preparations serve, it must be admitted, to give an aroma to the cordials, confectioneries, and sweetmeats, which are so largely sold nowadays. In other words, the products of industry are constantly taking the place of those of Nature more and more. In all these cases, these instances of composition of odorous principles are among the finest triumphs of organic chemistry. The creative power of the chemist is ever widening its range. After the labors of Piria, Wertheim, and Cahours, came those of Berthelot, who has imitated the fatty matters of the animal economy. We are at this moment in progress toward the artificial manufacture of sugar. If we succeed in that, nothing more will remain but to effect the composition of albuminous substances, in order to give us the complete mastery of the processes which Nature follows in her elaboration of immediate principles. That gift of making its object a reality, which is the peculiar privilege of chemistry, is also one of the strongest arguments to bring in proof of the absoluteness of those laws which we ascertain respecting the system of forces external to us.

Linnæus, whose mind was remarkably analytical and classifying, has not only arranged vegetables and animals in order, but has also classified diseases, and even odors. He refers the latter to seven classes: aromatic odors, such as that of laurel-leaves; fragrant, like those of lilies and jasmine; ambrosial, such as amber, musk, etc.; garlicky, like that of garlic; fetid odors, like those of the goat, the orrage, and others; disgusting odors, as those of many plants of the solaneæ order; and, last of all, nauseous odors. The terms of Linnæus have generally become current in language, but we understand, of course, that their value is merely conventional. As we have said before, there is no standard for the comparison of odors. We can only describe them by making comparisons between them, according to the degrees of resemblance existing between the impressions with which they affect our olfactory membrane. They have no qualities capable of being rigorously defined. This is the reason why it is impossible to give them any natural classification.

III.

The sensations produced by smells are perceived and judged of in a great variety of ways, though with less of difference than prevails as to tastes. "I have seen a man," says Montaigne, "fly from the smell of apples quicker than from a cannonade." The instance he alludes to in this passage is that of Quercet, Francis I.'s secretary, who rose from table and took flight whenever he saw apples upon it. History tells us that Louis XIV. could not bear perfumes. Grétry was greatly annoyed by the odor of roses; that of a hare caused Mdlle. Contat to faint. Odors which disgust us, like that of asafœtida and of the valerian-root, are on the contrary highly enjoyed by the Orientals, who use these substances for condiments. Among other singular instances related by Cloquet on this subject, we will mention that of a young girl who took the greatest delight in inhaling the scent of old books, and that of a lawyer to whom the exhalations of a dunghill yielded the most agreeable sensations. So that it is out of our power to fix general rules with respect to the influence of odors on our organs, and the character of the sensations which they effect in us; still, from a purely physiological point of view, it is certain that some of them exercise a uniform influence. Chardin and other travelers mention that, when musk-hunters take from the animal the pouch containing musk, they must have the nose and mouth covered by a cloth doubled in several folds, if they would escape violent hæmorrhage.

The smell of the lily, the narcissus, the tuberose, the violet, the rose, the elder, etc., when it reaches a certain point of concentration, usually exerts an injurious influence on the system. It occasions more or less severe headaches, fainting-fits, and sometimes even more serious disorders. Some odors, which have an agreeable perfume in a state of considerable diffusion, gain when concentrated a noxious and sometimes dangerous smell. This is particularly true of civet, patchouli, and the essences of neroli and thyme. Scientific records mention several cases of death occasioned by the poisonous action of some odorous emanations. It has been remarked that plants of the family of labiates, such as sage, rosemary, etc., offer in this respect no sort of risk, and seem rather to enjoy wholesome properties. Yet it is of consequence at this point to distinguish between the action of the odor which is in a manner purely dynamic, the intoxication from the essence, and the effect of carbonic acid thrown off by plants. These three influences have often been confounded by authors who have recorded accidents occurring after the inhalation, more or less prolonged, of odoriferous air.

This variable action of odors on the nervous system, sometimes wholesome, sometimes noxious, explains the part they have always played in the various circumstances of life among mankind. It would need a volume to relate the religious, political, economic, and gallant history of odors and perfumes. We must be content here with noticing its chief lessons, as far as they are connected with the physiological theory which is the basis of this study. For there is unquestionably something instinctive at the bottom of these general and uniform customs which exhibit the affinity of man for odors. Doubtless we must recognize in this rather a refinement of sensuality than a natural craving; but the same result has occurred in this case as in the instance of beverages, of music, etc. Habit has become in some sort a second nature; the senses have acquired a taste for that especial intoxication which beguiles them and disguises painful realities for them.

It is in religion, in the first place, that we observe the use of perfumes. Nothing holy or lofty was conceived of in which their influence was not present. Perfumes won the gods to give ear to the vows addressed to them in temples where burning incense diffused its fragrant clouds. From the highest antiquity we find that the priests of different religions avail themselves of the use of odoriferous substances. Five times a day the disciples of Zoroaster laid perfumes upon the altar where the sacred flame glowed. Moses, in Exodus, recorded the composition of two perfumes used in the sacred rites. The Greeks assigned a leading place to odors in their ingenious fictions of theology. They believed that the gods always declare their presence by an ambrosial fragrance, as Virgil tells us, in speaking of Venus;[1] and Moschus, describing Jupiter transformed to a bull. The use of perfumes in religious ceremonies had for its purpose the excitement of a sort of intoxication in the priests and priestesses, and also to disguise the smell of blood and of decaying matters, the offal of the sacrifices. The Christian religion borrowed from paganism the use of perfumes in the rites of worship. There was even a period at which the Church of Rome owned estates in the East devoted exclusively to plantations of trees yielding balsamic resins.

Besides these uses, odors were, in old times, still oftener employed in private life. Nothing surprises us more, in reading the ancient authors, than their relations on this subject. Among the Jews, the use of perfumes was restrained within proper limits, by the regulations of the Mosaic law, which consecrated them to worship. But, with the Greeks, it reached an extraordinary height and refinement. They kept their robes in perfumed chests. They burned aromatic substances during their banquets; they scented their wines; they covered their heads with fragrant essences at their festivals. At Athens, the perfumers had shops which were places for public resort. Apollonius, a scholar of Theophilus, left a treatise on perfumes which proves that, even as regards the extraction of essences, the Greeks had attained astonishing perfection. Neither Solon's laws nor Socrates's rebukes could check the progress of that passion. The Romans inherited it from Greece, and enlarged the stock of Eastern perfumes by those of Italy and Gaul. They used them profusely to give fragrance to their baths, their rooms, their beds, and their drinks. They poured them on the heads of guests. The awning shielding the amphitheatre was saturated with scented water, which dripped, like a fragrant rain, on the spectators' heads. The very Roman eagles were anointed with the richest perfumes before battle. At the funeral of his wife Poppæa, Nero burned on the pyre more incense than Arabia yielded in a whole year. It is related, too, that Plancius Plancus, proscribed by the triumvirs, was betrayed by the perfumes he had used, and thus discovered to the soldiers sent to pursue him. Besides the odors extracted from mint, marjoram, and the violet, which were the most common, the ancients made much use of the roses of Paestum, and various aromatic substances, such as spikenard, megalium, cinnamon, opobalsamum, etc.

It is singular to notice that the use of perfumes, brought to Rome with Grecian manners, was in its turn conveyed to France and Northern Europe with Latin manners, and chiefly by the Romish religion. It is from religious rites, indeed, that it passed into ceremonies of state, and thence into private life. Among the presents sent by

[1] "Then, as the goddess turned, a rosy glow
Flushed all her neck, and from her head the locks
Ambrosial breathed celestial fragrance round."

Haroun-el-Raschid to Charlemagne were many perfumes. In the middle ages, among princes and men of highest rank, they washed their hands with rose-water, before and after eating; some even had fountains from which aromatic waters flowed. At this period, too, it was the custom to carry the dead to their burial-place with uncovered face, and to place little pots full of perfumes in the coffins. The French monarchy always showed an unrestrained passion for enjoyments of this nature, which seemed created as a necessary attendant upon all others. Marshal Richelieu had so extravagantly indulged his passion for perfumes under every form, that he had lost the perception of them, and lived habitually in an atmosphere so loaded with scents that it made his visitors ill. Madame Tallien, coming from a bath of juice of strawberries and raspberries, used to be gently rubbed with sponges saturated with perfumed milk. Napoleon I. every morning poured eau-de-Cologne, with his own hands, over his head and shoulders.

IV.

Above all these questions which we have just skimmed, there rises another, of a graver and more mysterious kind, one which occurs at the end of all studies that treat of sensation, and with regard to which some reflections will not be out of place here. To what, outside of us, do those sensations which we experience within us correspond? What relation is there between the real world and that image of the world shadowed in our soul? In the special case we are concerned with, what is it in these substances which is the cause why they affect our sense of smell? It seems certain, in the first place, that odor in itself, so far as it is odor, is a mere figment of our mind. Contemporaneous physiology proves that excitement of the nerves of sensation is followed, in each one, by the sensation that corresponds with each. When we electrify the eye, we call up in it an appearance of light; when we electrify the tongue, we produce in it a sensation of taste; when we electrify the inside of the ear, we provoke in it the effect of a sound. So, too, a similar excitement, electric or otherwise, of the olfactory nerves, creates in our mind the sensation of smell, even though no odorous molecule takes part in the phenomenon. Sensation, therefore, seems to depend chiefly on the nature of the sensitive nerve. The external world seems to contribute to it only by setting in motion the nerve-fibres. Even this condition of an impulse impinging from without is not indispensable, since, in sleep and in madness, we experience sensations of smell which, by the testimony of our other senses, answer to no external agent. Still, we believe that we can distinguish cases of hallucination from cases of true perception; still, we maintain that there are, outside of ourselves, distinct causes of our distinct sensations. No skepticism has prevailed, nor will prevail, against this testimony of the most powerful evidence which exists in our inmost being. How can we account for this apparent contradiction? In reality, there is no contradiction. Observe, indeed, that, even if the most indifferent causes can effect in us one and the same sensation, and thus delude us as to the outer world, our soul is never cheated. It knows perfectly well how to refer this one sensation to the dissimilar objective causes which have affected it; in other words, the causes which are alike, and are confused in one in the purely physiological act of sensation, divide and grow distinct in the psychological act by which the soul recognizes them, and conceives them as different. If we had, to give us knowledge, only the dull and ignorant passivity of our senses, there would be no reality for us; but the wise activity of the soul can not merely assert the reality of outward objects, for a reason similar to that which makes it assert its own existence—it can still further argue, from its various modes of affection, to a corresponding variety of external forces. It moves in harmony with the world, rather than in harmony with the senses. In presence of the latter, it is like a good prince, who would be nothing without his subjects, but who regulates and civilizes them, by giving them laws, and ruling their morals. Thus, and this is the conclusion at which we aim, it is in the soul, regarded as the focus of all those rays refracted through the senses, as the central light outshining all others, that we must set the power and the right to discern what the senses do not discern, and to pierce to a depth forever beyond their reach. We shall never know what relation there is between the outward world and those images of it which we perceive, but the soul can hold the unshaken belief that the various points of those images correspond to points in the outer world situated in a like order, and that the forces which affect it are, in their essence, of the same nature as those forces of which, in its inmost depths, it feels itself the lord.

THE NATURAL HISTORY OF THE OYSTER.

By Rev. SAMUEL LOCKWOOD, Ph. D.

II.

IN the former article, attention was given chiefly to what might be called structural and industrial considerations of our bivalve. We are now to note some matters in the life of the oyster of a natal character. Its friends and enemies must be looked after. Its dietetics and geographical range must be dealt with. It must also be viewed in certain geological and ethnological aspects; for we may find even the oyster holding a singular relation to the American autocthonic man.

The Oyster's Birth and Growth.—According to the popular notion, which, in the main, is correct, the spawning-season of the oyster embraces those months which have no *r* in their spelling, namely, May, June, July, and August, the four warm months of the year. The fact is, that oysters generally do their spawning during these four months; but a few are liable to spawn whenever the water is warm enough, and large numbers pass through the year without spawning; and these, were it not for the difficulty of assorting them, would be available for food at any time. But the prejudice is universal against

Fig. 1.—Groups of European Oysters, of Different Ages, on a Stick of Wood.

their use during the *r*-less months. That they are not in as good condition then as during the cooler months, is reasonable to suppose; but that they are all necessarily unwholesome in the warm months, is far from being proved. In business phrase, oysters in spawning-time are said to be "milky." This means the presence of an opaline fluid in considerable abundance, and which has to do with the wants of its young—perhaps, remotely, a sort of fluid amnion. Our bivalve, however, does not spawn after the manner of mollusks generally. It is in its own way viviparous. It does not emit eggs; but, at the proper time, sends forth its young alive. The eggs are dislodged from the ovaries, and committed to the nursing care of the gill and mantel. At first, each egg seems to be inclosed in a capsule. It is of a yellowish color; but, as incubation or development progresses, the color changes, first to a gray, then to a brown, afterward to a violet. This is a sign that the time of eviction is at hand; for Nature now issues her writ to that effect. And wonderful little beings they are when the writ arrives to vacate the homestead; for whole troops of them can go gracefully, and without jostling, through the maziest evolutions in that tiniest sphere—a drop of water. As cited by F. W. Fellowes, in the *American Naturalist*, says M. Davaine: "Nothing is more curious than to see, under the microscope, these little mollusks travel in a drop of water, in vast numbers, mutually avoiding one another, crossing each other's track in every direction, with a wonderful rapidity, never touching, and never meeting." The parent-oyster has, indeed, a prodigious family to turn out upon the world. But when this time does come, though winter be near, her actions are summary, and the wee bairns are every one ordered from home. They are spit forth, or ejected from the shell. Filled with water, the valves are suddenly snapped together. Every snap emits a small, whitish cloud. Though a little of the milky fluid be in it, this whitish cloud is composed chiefly of the tiny fry; for, individually, they are almost invisible. Indeed, who shall count the oyster's offspring? Science, by her own methods,

FIG. 2.—THE SPAT.—OYSTERS JUST BORN, HIGHLY MAGNIFIED.

has made the computation; and so she gives us the astounding assurance that a single oyster, during one spawning-season, emits two million embryos! Each one, though scarcely larger than a pin-point, is a lively little affair; and such an odd little fellow, too! In fact, it has scarcely any resemblance to its parent, either in external form or internal anatomy; while, in habit, it differs as widely as does the flying bird from the burrowing mole. Let us look a moment at Fig. 2. These are young oysters just sent into the world. They are not so large, by a good deal, as an ordinary pin's-head. How angular the shell is! And the internal organization is, as yet, very simple. And what a strange, brush-like appendage! That fleshy pad is its locomotive organ; and a very funny, but quite pretty contrivance it is. The projected pad is encircled by a frill of cilia, or fleshy hairs, arranged much as the frill is around the large pin-cushion which occupies a place before the mirror of a lady's boudoir. As these cilia play together, the illusion is produced of a revolving wheel; and, in fact, it is the uni-cycle velocipede of this baby-voyager, with which it must do some traveling in quest of a home, or permanent settlement for life. This frilled organ can be projected and withdrawn in rapid alternations. While being projected, the circular frill expands, thus achieving a very efficient propulsion. And, while being withdrawn, it contracts, or is involved within itself, in this way presenting the least possible resistance to the water. This mechanism, as I understand it, is as remarkable as it is beautiful. It fulfills perfectly, or certainly to a remarkable degree, the conditions of perhaps the most perplexing of the unsolved practical problems in naval science—the attainment in union of the maximum power of propulsion and the minimum resistance from back-water.

If we examine a snail, or conch, as typical of the univalve mollusks, or shell-fish, we shall find the organs of sense, mouth, tentacles, and eyes, so arranged together as to entitle the object to be known as a cephalate mollusk, that is, one which has a head. The bivalves are not so highly organized, and are acephalate, or headless. It is a curious fact, however, that in the larval state many of these bivalves have eyes, though they lose them as growth proceeds. Although we think it probable, it has not yet been proved, that the larval oyster has eyes. To witness the merry high time of these juveniles, it would seem that they both have eyes and are bound to use them, too, in seeing something of the world; for, as if eviction entailed neither disgrace nor inconvenience—as with certain bipedal juveniles under pupilage—off they go in the wildest glee imaginable. But the gay frolic is soon over. A few settle down, like the old folks, to a sober life. Alas! it is with the rollicking young oysters as with many other young people—this wild-oat sowing yields a fruitful but perilous harvest. Of each million that enter upon this dissipation, but a few hundreds, at the most, survive. Many have been devoured by hungry enemies lying in wait, and many went to sea, and, unable to return, perished miserably. The survivors attach themselves to any thing that offers an anchorage; and these are called "spat." Fig. 1 contains five groups of oysters of as many different ages, all of which, by a professional oysterman, would be called "spat," excepting the three largest at the top. The attachment is made at the lower valve. And, now having wound up its giddy career, what was done with the velocipede? In plainer words, what is to become of the locomotive pad, for which it has no further use? It begins to disappear—not by atrophy, however, nor is it sloughed off in any way. Herein appears one of Nature's economic processes; for the pad is *absorbed*, literally consumed, and the baby-oyster in this way gets a start that secures it a rapid growth—for it should be borne in mind that this is a critical period in the life of this diminutive thing. It is just now that it has to draw so largely on its small capital of vital resources, by directing the growth-force to the one object—a sure anchorage. Thus the secretions labor on the cementation of the lower valve to some solid object. Then comes the general shell-growth, which is very rapid, and at the same time the accelerated internal development; all which amounts to an entire reconstruction.

If, now, to this triple draft, occasioned by the anchoring, the shell-growth, and the development of the internal organs, one should add the necessity of procuring food in the usual amount, and by the usual means, would not the combined demand be exhaustive beyond the little creature's powers and resources? It should be observed, too, that now the food-necessity is more urgent than at any other period of its existence. It is also observable that the banquet prepared is ampler than at any other time. This is surely a striking instance in lowly quarters of a wise conservation of material and force. I am aware that this pad is differently disposed of by some naturalists; that it is said to drop off, and to be wasted; but, as I have witnessed a similar utilization of an otherwise useless member in other larval forms, I believe that observation will establish this view. And how remarkable this internal change, so rapidly progressing in the little oyster! It is a series of almost magic transformations. The eyes—if it had any—are gone. The external cilia, which served it for locomotive and breathing organs, disappear, and within appear true branchiæ, like those of its mother. A stomach, too, is now built up, and the labial fingers are provided. And that tiny, true heart appears, to the music of whose beating the little creature begins in earnest its life-work, as a perfect oyster, although hardly yet larger than the head of a pin. When a month old, it equals a large pea in size; at six months, it is an inch or more in length; at four years, it is large and amply ready for market, or even at three years, if the conditions of growth have been favorable.

The Oyster's Companions.—For raising the seed, that is, the young oysters intended to be planted, a hard bottom, with plenty of shells, or objects for attachment of the spat, is desirable. But such a location would not be the place for growing and fattening the adult. A bottom with two or three inches of organic mud, and a hard pan beneath, and that in an estuary, or somewhere commanding a current, and receiving the river-flow, is the best. In this flocculent organic mud is much of the food of the oyster, and this food is in lively motion upon its surface. The algæ, or sea-weeds, often anchor to the shell, and adorn it with fronds of olive, and ruby, and the most exquisite emerald, while the sporules which rain from them are the true manna of the oyster. The elegant red sponge, with its clustered lobes, almost like chalina, is sometimes found perched on the upper valve, like a great showy cockade. When, many years ago, before the Southern oyster was planted North, they used to take up the rich "naturals" around Bedloe's Island, this beautiful native sponge was often found in great tufts as large as a peck-measure. The oystermen called it "red-beard;" and often might be seen, at the door of an oyster-saloon in New York, a heap of these choice oysters, surmounted by a grand specimen of this red sponge. Even yet, at Craney Island, where the Elizabeth River and Hampton Roads meet, are acres of this pretty sponge. This sponge often renders a singular service to some fine old bivalve sinking with the weight of years into the rich organic ooze. It actually buoys it up, and rocks it, so that the under valve becomes white and bright with the gentle friction. In the crevices made by the lapping shoots on the upper valve, like tiles on a roof, are often found tiny univalves, sharing in the crumbs of the banquet on which the occupant of the great house feasts. We have often with

Fig. 3.—Flustra Foliacea.—A Community of Bryozoa growing on Oysters and other Objects.

a penknife pried them out of their hiding-cracks, although much smaller than a grain of rice. Often, too, if examined closely, an oyster-shell may be found partly coated with a delicate net-work, as if some fine Valenciennes lace had been cemented thereon. These are the skeletal cells of the *Bryozoa*, or animate moss; for, though like moss somewhat, the little builders are living creatures, and, under the microscope, a bit of a live bryozoan-patch would look like a bed of living daisies, for these flower-forms are in lively motion in every part. Sometimes these communities of moss-like animals, such as are known under the generic name *Flustra*, build their structures up like plants, and literally embower the oyster in the most exquisite of fairy groves. The cut *Flustra foliacea*, Fig. 3, represents a European species. Its fronds, so to speak, are flat, and spatula-formed. With its gracefully-spreading lobes, like fronds, it has often been mistaken for an alga, or sea-plant. If you will only look closely at this cut of *Flustra foliacea*, Fig. 3, it will be seen to be full of minute cells. A look at Fig. 4, 1, will make this plainer, while in Fig. 5, 1, by greatly magnifying, the form of these little chambers in one of the species is shown. The naturalist, speaking of the entire establishment of one of these communities, calls it *Cœnœcium*, which means the common house of all the indi-

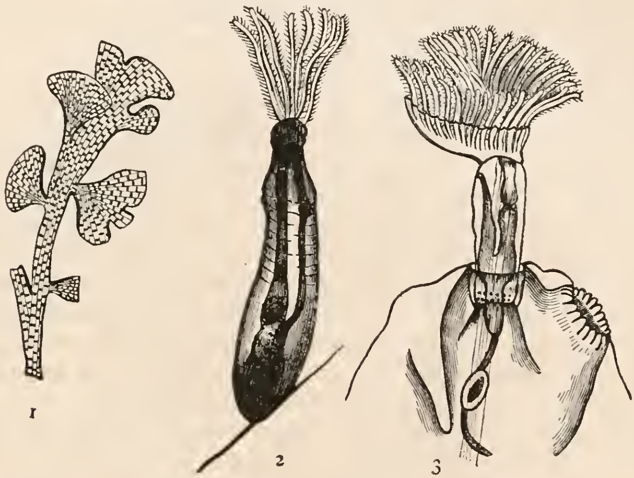


FIG. 4.—1. FRAGMENT OF FLUSTRA TRUNCATA, NATURAL SIZE; 2. A single polypide of *Valkeria* magnified to show its crown of tentacles; 3. A polypide of *Lophapus crystallinus*, a fresh-water polyzoon highly magnified, showing its horseshoe-shaped crown of tentacles.

viduals collectively; for each one of these little crypts, or chambers, is the exclusive apartment of one zooid, or individual member of the community. At the portal of this little crypt the occupant, when hungry, presents itself, and retires at its pleasure. When it does show itself, with tentacles spread, some idea of its individual beauty may be got by looking at the magnified tufts, like floral crowns, as shown in Figs. 4 and 5. When an entire community, or even a considerable part, is out airing, could one but see it, the sight would be very fine, for the smallest fragment in the microscope looks like a bed of daisies.

The oyster is often literally embowered in a substance that looks like diminutive trees. Its color varies from a reddish to a very pale brown, almost gray. The oystermen call it "gray-beard." Shore-visitors often pick up tufts on the beach, and press them for sea-weeds. They are really the skeleton structures of a remarkable zoophyte, the Sertularia. We have an elegant species that grows upon the oyster, named *Sertularia argentea*, because it is often so white and glittering that it looks almost like silver. These I have found sometimes sixteen inches high, making the most exquisite gossamer-tree. But it is no tree or plant proper. Their substance is chiefly lime. They might well be called sea-ferns. When magnified, living specimens show what might be mistaken for little buds. If the microscopist is both skillful and patient, he will see a little starry object like a flower push itself out of one of these buds, which is really its case in which it lives. It may be seen waving its little life-petals about, catching food. I have not forgotten the delight experienced when I found out this fact for myself. Let the reader dwell a moment on Fig. 6. The Sertularia buoys up the oysters, as does the red sponge. And one may readily conceive how the animalcules must swarm in these gossamer-like forests or groves, so that not only the zooids but the oyster also enjoys the richness of the fishing-ground.

Everybody, that has seen any dredging in Long Island Sound, knows that lumps of matter made up entirely of small calcareous tubes abound there. These tubes are often found adhering to the oyster; in fact, these animals build them on the oyster's shell. Its name is *Sabellaria vulgaris*, so named by Prof. Verrill. The constructor and occupant is a worm, but, for all that, a creature of surpassing beauty. In company with this, another little being builds a tubular home on the oyster. It is a small serpula or serpent-shell, and is called by Verrill, *Serpula dianthus*, the pink serpula, because, when the little dweller therein projects its tiny florets, in form and color they suggest the pink of our gardens. But there is projected by the side of that pretty little pink, a curious, funnel-shaped process, that looks like the tiniest kind of a trumpet. We have watched those pretty creatures with their floral heads out fishing. Let the slightest jar be given, and the little thing takes alarm and instantly withdraws into its stony tube: first the floral head disappears, then the trumpet-like structure is drawn in, which actually plugs up the entrance. All this will be understood from Fig. 7, which shows a serpula. The spirorbis here figured is really a serpula, a tube coiled into a spiral. I have never seen the spirorbis growing on the oyster-shell, but have taken it from sea-weeds and Bryozoa thence obtained.

This natural plug, or stopper, is not without a smack of drollery. At least it has always impressed me as having in it a taste of the intensely utilitarian. And this reminds me that, in all their beauty, there is also a savor of the comical in the Bryozoa. Please to look at that *Avicularium* in Fig. 5, 3. Is it not like the head of an eyeless bird? To see this "bird-head process" at work, one feels irresistibly that it is a real zooid, an individual among the Bryozoa, and Huxley seems disposed to favor such a view. However, I believe all the proof as yet is on the side of its being a process, an organ, so to speak. Now, there are a good many of these bird-heads in the community, and very useful things they are. Let an animalcule too large for prey come fooling around these little Bryozoa, and one of the bird-heads will give it a nip such as to make a second one unnecessary. But these Bryozoa are in danger of being cloyed with dirt. These bird-heads, like so many ants, pick off the annoyance. Is not all this

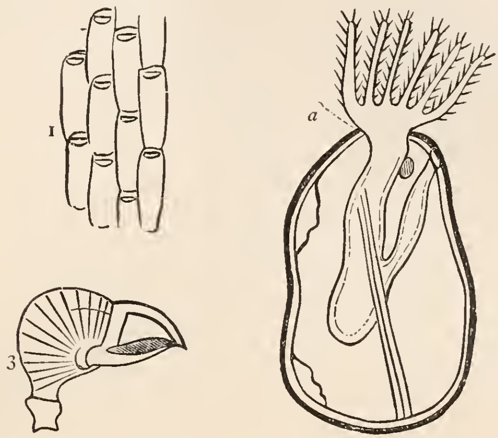


Fig. 5.—Anatomy of a Bryozoon.—1, the skeleton cells; 2, diagram of an individual Bryozoon; *a*, the region of the mouth surmounted by a crown or tuft of tentacles; 3, an *avicularium*, or bird's-head process.

pretty? And it is quite ludicrous, too. And why should not Nature like a wee bit of drollery now and then?

If a pile of oysters be examined soon after leaving the water, especially if taken off a pretty clean bottom, a number of specks, about a quarter of an inch in width, may be seen adhering to the oyster, chiefly the upper side. They look like grease-spots, or small lumps of jelly. They are little sea-anemones, collapsed and dead. Alive in the water these are pretty objects, having a disk of a flower-form, with an orifice in the centre which opens into the animal's stomach, and which is really its mouth. (*See* Fig. 8). Such, then, is something of the oyster's environment. With such surroundings, so much of beauty, with a spice of Nature's humor, just enough to make this beauty true and pure, on the principle that a person is known by the company he keeps, the oyster might be set down as an individual of refined tastes.

Something should be said of the oyster's most intimate and familiar friend, a certain dapper little fellow in a scarlet jacket with trimmings of gold. From its size and form it is sometimes called the pea-crab; but, from the fact that it is only found in the oyster, it is generally known as the oyster-crab. Fishermen have insisted to me that it was the young of the edible crab. No naturalist, not even a tyro, could make this mistake. Naturalists have named this little crab, *Pinotheres ostreum.* Usually it is the female that one finds in the oyster. The male is much more rarely met with, and is smaller than the female, and of more sombre coloring. A dull brown is the predominant hue, though the legs are white. On the back is a figure remarkably like an anchor, done in white. But the history of the oyster-crab is imperfectly known. For aught that we have been able to learn, this pretty little crab is a harmless commensal. Whether it is always welcome by its entertainer we cannot say, but this is sure, Pinotheres has always been known as the oyster's bosom friend.

There is a story that General Washington was very fond of these oyster-crabs, and that, knowing this fact, a lady admirer, at whose house in New York the general was to dine, had an understanding with the different oystermen of the city, and their combined efforts got together half a pint of these diminutive crabs, which were served up and set before that eminent man, greatly to his surprise and delight. In the season, this little crab is readily obtained put up in half-pint bottles. Now that they have become a staple luxury in the city markets, why do not our epicures call them "Washington crabs?"

The Oyster's Enemies.—The above must be set down as the rosy side of oyster-life, for they are a much-persecuted race. Though a sober people, always leading quiet lives, yet they seem to be regarded on all sides as possessing no rights that others are bound to respect. Let us make a visit to one of these orderly communities in Oysterdom known as a "planting-ground." We are seated in a boat, and, gliding through the phosphorescent sheen, soon near the oyster-bed. It is a moonlight night, about the close of summer. Hark! what singular sound is that? Boom! boom! boom! Almost sepulchral, and, strange to say, it comes up from beneath the waters. One would think they were Nereids' groans. The oystermen, whose capital lies invested there, hear it with sad forebodings of loss, which they cannot well sustain. It is one of a school of visitors who come with marauding purpose. The fishermen call it the big drum. This drum-fish is known among naturalists by the name *Pogonias chromis.* The acknowledged beat of this scamp is the Gulf Stream, from Cape Cod to Florida; and a terrible fellow is this Pogonias, for he is recorded as having attained the great weight of eighty pounds. One of twenty-five pounds would be but an ordinary affair. Their mouths are furnished with pavements of hard teeth, a little rounding on the top, and set together exactly as are the cobble-stones of the old city highways. The function of these dental pavements is to crunch the young oysters, which after being crushed are thus swallowed, shells and all. As these monsters come in shoals, they sometimes inflict serious damage on an oyster-bed. Not long ago, at Keyport, New Jersey, a visit of this character cost the oyster-planters some $10,000. Said "an eminent naturalist," "No fish has teeth strong enough to crush oyster-shells." This is certainly a mistake. I believe that oystermen regard a three-year-old oyster as comparatively safe in this respect, and their apprehensions appertain to the younger beds.

FIG. 6.—SERTULARIA PINNATA.—*a*, a fragment, natural size; *a'*, small portion magnified; *o*, shows the case of a male zooid; *b*, *Campanularia neglecta*, magnified.

At Long Branch, and in fact pretty much on the entire eastern seaboard, is often found the periwinkle, or great sea-snail (*Lunatia heros*). These are quite numerous. Oystermen have gravely told me that this animal kills the oyster. It has an operculum, or cover to the mouth of the shell, and they say that with this, as a knife, it opens the oyster. All this one might believe but for two difficulties: first, you could as easily open an oyster with the edge of a lady's visiting-card, for the operculum is of soft horn, and not thicker than a card; secondly, this Lunatia is not lunatic enough to try the experiment, as it is constitutionally a strict vegetarian, living upon the juicy sea-lettuce, and other algæ, so that on dietetic principles it has serious objections to the bivalve.

There is a small univalve, seldom much over an inch in length, which is justly chargeable with murderous assault on the oyster. The watermen very properly call it the drill. The latest name it has received from the conchologists is *Urosalpinx cinerea.* It is, however, more generally known among scientific men as *Buccinum cinereum.* It is a very pretty shell. The tongue is set with three rows of teeth like a file; it is, in fact, a tongue-file, or dental band, and is called by conchologists the lingual ribbon. (*See* Fig. 9.) This tongue-file is perfectly flexible, and with it the Buccinum drills a hole through the hard shell of the oyster. Owing to the fact that, when using this dental ribbon, the broadly-spread pedal disk hides it, the exact method of the operation is concealed. Having with the utmost care witnessed a number of times the creature in the burglarious act, I give the following as my view of the case: With its fleshy disk, called the foot, it secures by adhesion a firm hold on the upper part of the oyster's shell. The dental ribbon is next brought to a curve, and one point of this curve on its convex side is brought to bear directly on the desired spot. At this point the teeth are set perpendicularly, and the curve, resting at this point as on a drill, is made to rotate one circle, or nearly so, when the rotation is reversed; and so the movements are alternated, until, after long and patient labor, a perforation is accomplished. This alternating movement, I think, must act favorably on the teeth, tending to keep them sharp. To understand the precise movement, let the reader crook his forefinger, and, inserting the knuckle in the palm of the opposite hand, give to it, by the action of the wrist, the sort of rotation described. The hole thus effected by the drill is hardly so much as a line in diameter. It is very neatly countersunk. The hole finished, the little burglar inserts its siphon or sucking-tube, and thus feeds upon the occupant of the house into which it has effected a forced entrance. To a mechanic's eye there is something positively beautiful in the symmetry of the bore thus effected—it is so "true;" he could not do it better himself, even with his superior tools and intelligence.

Oystermen also complain of ravages perpetrated by the great conch. But there are two of these conchs, widely distinguished by naturalists. One of them has the upper edge of the whirls ornamented with a projection, with bosses at uniform intervals: this is the keeled conch, and is called, by Conrad, *Fulgur carica*. The other one has a canal or groove running round the shell, on the top of the whirls: this is the grooved conch, and it has lately been named, by Gill, *Sycotypus canaliculatus*. The oystermen say that these conchs "rasp the nib of the oysters;" and with their large tongue-files this is not hard to do. It is certainly going a great way for an analogous case; but I have examined numbers of the first-created oysters, fossil oysters, in the New Jersey Cretaceous formation, and have found not a few among them which had received precisely that treatment from certain ancient carnivorous gasteropods.

But the most insidious foe to the life and peace of the poor oyster is the star-fish. The American species, which does the mischief, is the green star-fish (*Asterias arenicola*). The species obnoxious to the European oyster is the red star-fish (*Asterias rubens*). (*See* Fig. 10.) The sea-star does not like water that is too brackish; that is, it loves salt-water. Whenever the Shrewsbury River is affected by the breaking in of the sea, there is danger for its celebrated oysters. On several occasions, at such times, the star-fishes have come up in great numbers, and utterly destroyed the bivalves. At one time so great were their numbers, that they were thrown up on the shore in large, loathsome, squirming balls. Says Verrill, "In one instance within a few years, at Westport, Connecticut, they destroyed about 2,000 bushels of oysters, occupying beds about twenty acres in extent, in a few weeks, during the absence of the proprietor."

It is curious to read the silly stories that are told in the name of Natural History. There is one that says that the star-fish puts its fingers or rays into the oyster's shell, and helps itself. From every point of consideration the thing is ridiculously impossible. A more sober judgment is that given by some naturalists, namely, that the sea-star protrudes its great sac-like stomach, and envelops to a great extent the oyster therein, and so leisurely digests the mollusk out of its unopened shell, much as a codfish does the shells it swallows.

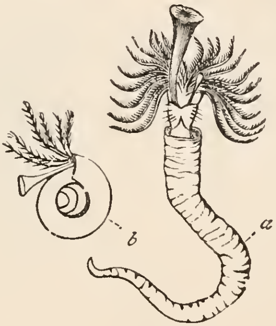


Fig. 7.—Tubicola.—*a*, *Serpula contortuplicata* ; *b*, *Spirorbis communis.*

After having seen young star-fishes eat small specimens (that is, such as were suited to their size) of oysters, mussels, and scollops, which I have fed to them in an aquarium, I give the following as based on a number of observations : Having brought the oval, or stomach orifice, exactly opposite the nib of the oyster, the star embraces the bivalve with its five flexible rays, aided by the hundreds of sucking-disks on the tiny feet. Thus positioned, the star-fish clings firmly, but keeps itself quite still, and waits very patiently. After a while, the instinct of the oyster will be at fault, and it will open, as if no enemy were near. At this moment, as it seems to me, is injected from the oral orifice of the star a baleful "sidereal blast." It is a something that paralyzes the mollusk ; because, from that moment the valves of the oyster are opened to their full extent, and the hold of the flexible rays is relaxed. Instantly a singular variation of the performance sets in. The rays are withdrawn and set back to back—the stomach is protruded, and the doubled-up star intrudes itself into the oyster, the evicted stomach leading the way in the movement, and absorbing its victim. If the famous "India-rubber man" could throw backward his arms, legs, and head, and in this position could then infuse himself, stomach-first, into a partially-opened writing-desk, he would rival this feat of the sea-star, without the villainy of injecting chloroform through the key-hole.

But the oyster race has one foe more formidable than all the rest—one who invades their ancient waters with iron implements and hungry fleets—who brings to his service the appliances of a high intelligence, and the impulsion of an imperious necessity—who, after the strictest rulings of the old barbaric cannibals, assigns the adult captives to immediate immolation, and reserves the young to be grown and fed for a future feast. And everybody eats the poor oyster—

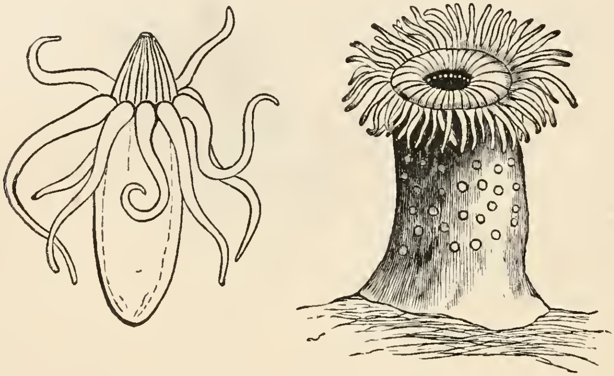


Fig. 8.—Sea-Anemones.

prince and peasant—the healthy and the sick; even he who is paying the penalty of long defiance to a stern physical law, and to whom all food is suggestive of torture, thinks he might stand an oyster or two. The rollicking student, brimming full of frolic and swagger, emerging from his day's course on the humanities, fancies that oysters make a good dessert after such dry pabulum. In fact, he holds the bivalves in so high esteem that he informs "Chum," sentimentally, of course, that he thinks oysters should be called *pabula amoris*, and proposes a dozen each on the half-shell. So the saloon-man prepares for the immolation. With the implement of his calling he taps at the passageway, "The gate's ajar." Treachery! The iron enters the soul! Chum takes the initiative. The mollusk approaches the lips—and—it is gone! There is a gleam in Chum's eye—a flash ecstatic; it is the light of genius satisfied. "Tom, it is the elixir of the gods solidified! How it went down like a chunk of bliss! *Facilis descensus Averni.*"

It is a pity that candor should compel one to seem to spoil this fine Roman sentiment by quoting Roman practice. But we cannot cover up history; and we are the less willing to do so, because we are about to cite transactions that will prove the great wrongs suffered by Ostrea, for so these Romans called our oyster. The chroniclers tell that the Emperor Vitellius could eat a thousand of these bivalves at a meal. What vitals must this Vitellius have had! Who would dare undertake to victual such a glutton as that? It is said of that gentle wag, Charles Lamb, that, on a certain occasion, the omnibus in which he rode was stopped by a man, who poked in his head and bluffly asked, "All full in there?" To which Lamb meekly made response, "I don't know how it is with the rest—but that last piece of oyster-pie did the business for me!" But this Vitellius was not so easily done

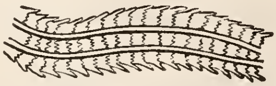


Fig. 9.—Fragment of the Tongue-file, or Lingual Ribbon, of the Whelk (*Buccinum undatum*), magnified.

for as that comes to. Having engulfed his fill of these ostrean innocents, this royal gourmand would open the sluice-gate of his kingly maw, and cause a slave to tickle the fauces with a peacock's feather. This, acting as an elevator, effected a full discharge of the beastly cargo of that carnal vessel. This done, that ostreaceous appetite would load up afresh. Would not the evertible stomach of a star-fish have been an inestimable blessing to that imperial beast?

Dietetics of the Oyster.—Are oysters good to eat? Said Montaigne, "To be subject to colic, or deny one's self oysters, presents two evils to choose from." This is very fine for Montaigne, but it is a libel for all that. Besides, he was a sickly man at best of times. Says Reveille-Paris: "There is no alimentary substance, not even excepting bread, which does not produce indigestion under given circumstances, but oysters never. We may eat them to-day, to-morrow, eat them always, and in profusion, without fear of indigestion." It is said that the first Napoleon always ate oysters on the eve of his great battles, if they could be got. Says Figuier: "The oyster may thus be said to be the palm and glory of the table. It is considered the very perfection of digestive aliment. . . . The small proportion of nutritive matter explains the extreme digestibility of the oyster." It "is nothing more than water slightly gelatinized." But, if we would have authority the most recent, and thoroughly trustworthy, let us go to that little book in the "International Scientific Series," "Foods," by Edward Smith, M. D. Here we have the dictum of the physiologist: "The oyster is not a food of high nutritive value, but is nevertheless useful to the sick, while its delicacy of flavor leads to its selection when other foods are rejected. The more usual mode is to eat it when uncooked; and it is very doubtful whether cooking increases its digestibility. It is, however, possible that the flavor of scalloped may be preferred to that of the raw oysters, or that the vinegar which is usually eaten with the latter may be disliked, or may disagree with the stomach, but, with such exceptions, the usual method of eating them raw is to be preferred" (page 116).

Americans, I believe, are the only people who eat the so-called soft-shell crabs; that is, crabs at the time of having cast the skin. It is not at all probable that, at such a time, the animal is wholesome food. And so with oysters, during the spawning-season, it is wiser to abstain, for the reason that one is not sure that the oysters we are eating then are not in a spawning state. In its normal condition the oyster is excellent food; and, if we assign it its rank among the shell-fish, it will be, without dispute, the queen of the bivalves.

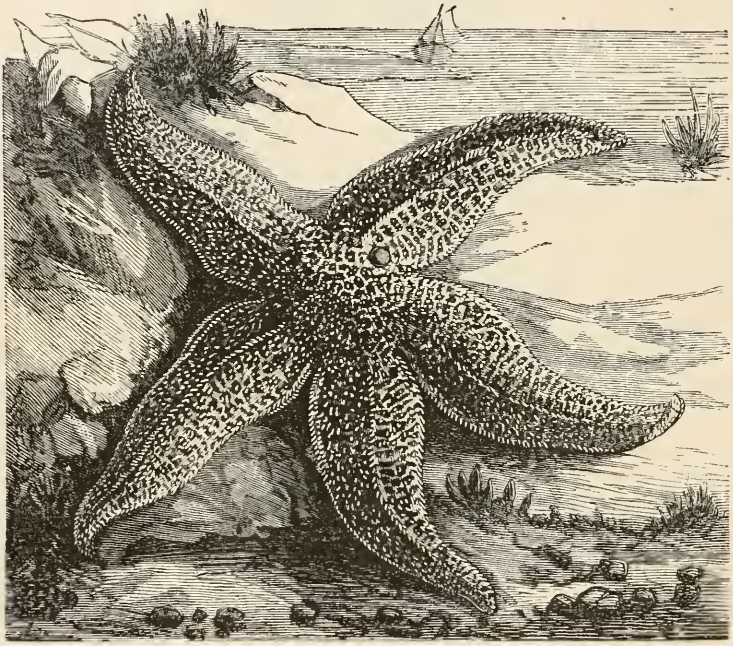


Fig. 10.—Asterias Rubens, a European Sea-star, or Star-fish.

Some Facts, Geographical and Ethnological.—Says Figuier, Virginia has 2,000,000 acres of oyster-beds. In many places they grow so thickly that they make immense mounds in the water, the lower oysters being killed by those above. Even mouths of the sea have been closed by them, says Dr. Smith. Certainly in this particular the wealth of Virginia and Maryland is immense. In former times all the suitable waters of New York and New Jersey abounded in native oysters. There are those yet living who remember the custom of the farmers to go with their wagons to the shore at or near Keyport, New Jersey, to gather "natural" oysters. There is a curious old map in existence which will, we predict, become famous as an authority in the appeals of State diplomacy. It is dedicated to Governor Moore, of the province of New York, by its author, who signs himself "B. Ratzer, Siuv'r in His Majestic's 60th American Reg't." It is a map of the city of New York, and it gives the waters of the entire harbor, with their soundings. Its date is 1767. A large tract of water is marked "The Oyster-Banks." In that area of what was then fine native oysters is now the vast patch of "made-land," laid down by the filling in of the city's refuse, by the New Jersey Central Railroad, and which matter is now in litigation. The time was when the entire waters west of the channel, beginning south of Jersey City, and surrounding Ellis and Bedloe's Islands and Robbins's Reef, and a little way beyond Constable's Point, up the Kill Von Kull, altogether some six miles in a straight line, was a rich bank of native oysters, and supposed to be inexhaustible. It can hardly be questioned that, when the European settled here, that which is now the eastern coast-line of the United States contained, by several times, more of these edible bivalves than did all the rest of the world. The very shells left inland in many places, by the aboriginal oyster-eaters, make mounds of vast extent, in some instances thirty feet high. At Fernandina, and other places in Florida, they were used as forts in the late war. As to their antiquity, there can be no doubt that oysters were eaten there thousands of years ago.

Recent ethnological investigations indicate, at least, the strange fact that the people who began those shell-heaps antedated the supposed autocthones of the American Indian. Their bones have been discovered, and they show an osteology not known among any of the red-men of to-day, namely, a flattening of the tibia, or shin-bones. The relics of the great mounds have shown the same fact; and so marked is this, that the name *platycnemic*, or flat-shinned, is proposed for this ante-historic race. Again, the unpleasant fact is also indicated that these same ancient oyster-eaters were cannibals. And those heaps of oyster-shells on the land, in which are mixed relics of the ancient races, extend from Florida to Maine. They are found on islands in Casco Bay. But the oyster is not an inhabitant of these parts to-day. In fact, it is a sort of fossil; so that some great geological change has taken place on our coast since those times in the long ago. This surely points to a great antiquity of these autocthonic oyster-eating men. And the several facts just enumerated would indicate the extraordinary prevalence of this bivalve on our Eastern coast. The most ancient name of Britain is Albion, with evident allusion to its white cliffs. If this truthfully characterized the Druid-Land, it surely would not have been less appropriate, nor less poetical, had the first adventurer named this Occident shore the Oyster-Land.

So, then, how potent has been the influence of the oyster in the industries, and morals, and convivialities of the ancient and the modern man!

SOME SUPERSTITIONS OF HYDROPHOBIA.

By CHARLES P. RUSSELL, M. D.

THE reign of Sirius is over, and the dread of hydrophobia has ceased to agitate the public mind. At this auspicious season of the year we may approach the subject with cool premeditation, and deal with it in our own way. No longer do we regard our canine associates with a sort of indefinable apprehension. Our Spitz "Prince" pursues with savage intent the obnoxious house-fly, without exciting any suspicion of "snapping at imaginary objects in the air." His appetite is capricious, and we merely sympathize with him as a fellow-sufferer from dyspepsia. He bites a part where crawls the occult flea, without having to undergo a critical examination for a "point of injury." He retires in dim seclusion under the sofa, and indulges in reverie—disagreeable reminiscences of the past, grim contemplations of the present, and perhaps gloomy anticipations of the future—without having his moroseness misinterpreted. He becomes uneasy and fidgety, even peevish and ugly at times—what then?—like master like dog, he serves to illustrate our human moods. Occasionally he displays toward us an exaggerated degree of affection almost unaccountable in any Prince of mature age; but this is in the early morning, and the odor of his favorite liver ascends from the kitchen; even his blandishments, alas! are sometimes selfish. He is now permitted to run through the street without a muzzle, and to consort with the *οἱ πολλοι*—"the great unwashed"—of his tribe; which affiliation he thoroughly enjoys, albeit a dog of most aristocratic pedigree—remembering, possibly, that both his descent and theirs are by many naturalists derived from a common and somewhat disreputable ancestor named Wolf. In fact, the dog-days being past, his follies, his faults, all his vagaries, seem natural as ever. How is it, we now ask ourselves, that this faithful servant and friend should have been under such a cloud during all the bright summer? Why, as Mr. Mayo has remarked, should he be regarded at that particular season as being subject to "a sort of dog-lunacy, having the same relation to Sirius that insanity has to the moon—which, indeed, in another sense, is probably true?" The answer may be found in that peculiarity of human nature which clings fast to traditions and superstitions, and will most probably always do so until man ceases to be human. It is the province of science, however, to battle with these familiar foes, and to at least surround with invincible lines the almost impregnable positions in which Time has intrenched them among the credulous and ignorant.

The mysterious influence of the "dog-days" upon the canine race is an opinion of the greatest antiquity, dating back apparently to Anubis, the dog-form of the Egyptian Apollo, whose appearance in the heavens was a premonition of impending danger. It probably also had some connection with the Κυνοφόντις ἑορτή, a festival of the Argives marked by the destruction of many dogs. In the "Iliad," Homer mentions Orion's dog as affecting human health disastrously. Pausanias, in his "Travels in Greece," alluding to the story of Actæon's destruction by his own hounds, was inclined to attribute the myth to the circumstance that the season had caused the pack of the famous hunter to run mad. Pliny remarks, in his "Historia Naturalis," that "canine madness is fatal to man during the heat of Sirius, and proves so in consequence of those who are bitten having a deadly horror of water. For such reason, during the thirty days that this star exerts its influence, we try to prevent the disease by mixing dung from the poultry-yard with the dog's food, or else, if he is already attacked with the disease, by giving him hellebore." From the time of Pliny until quite recently the development of rabies by summer heat has been accepted as a fact among scientific men, and the idea has become too deeply rooted in the popular mind to be easily eradicated. Only within the present century has it been proved conclusively by critical inquiry that no season of the year is specially concerned in the production of this formidable affection. Hence the absurdity of legislative enactments designed as precautionary measures against hydrophobia, and operative only during the summer months.

Our old and esteemed friend Pliny is responsible for several other very remarkable statements with regard to the dog. He asserts gravely that dogs will run from any one having a dog's heart about him, and will never bark at a person who carries a dog's tongue in his shoe under the great toe, or the tail of a weasel which has been liberated after being deprived of that appendage. Among various absurd preventive means which he recommends, as efficacious in the case of a person bitten by a mad dog, is, to insert into the wound ashes of hairs from the tail of the animal which inflicted the injury. Hence the half-sick reveler, as he imbibes his morning potation, assures himself of its curative effect in the remark that he is taking "a hair of the dog that bit him."

The same author informs us of a belief common among the Romans, that a dog which laps the milk of a woman who has had a male child will never become rabid.

Another singular tradition, handed down from remote antiquity, but popularized by Pliny, is the idea that beneath the dog's tongue is situated a worm whose existence encourages the development of hydrophobia, and whose extirpation in puppyhood is an infallible preventive of the disease. He thus alludes to it: "There is in the dog's tongue a small worm known as 'lytta' among the Greeks. If this be removed from the animal while a pup, it will never become rabid or lose its appetite. This worm, after being carried thrice around a fire, is given to persons who have been bitten by a rabid dog, to prevent their going mad." There is a curious correspondence between this recommendation of Pliny's and the following recipe for the "tear of a mad hound," found in an old Anglo-Saxon leech-book, written about the commencement of the eleventh century, entitled "Medicina de Quadrupedibus:" "Take the worms (thymas) which be under a mad hound's tongue (under thede hundes cunzan), snip them away, lead them round about a fig-tree, give them to him who hath been rent; he will soon be whole."

Allusion is made to this worm in a work called the "Kynosophian," supposed by some to have been written by Phæmon, while others attribute it to Demetrius Pepagomenos, a Greek writer residing at Constantinople in the twelfth century. In this book it is asserted that underneath the dog's tongue is a little body like a white worm, which must be quickly destroyed ere it increase and invade the whole throat. In the sixteenth century, Fracastorius, in a poem styled "Alcon, sive de cura Canum Venaticorum," refers to it in the following words: "Vulnificus *vermis* suffunditque ora veneno."

In more modern times, the Germans generally believed in it, terming it the *Tollwurm*, or *worm of madness.* So popular was the superstition, that, in the middle of the last century, there existed in Prussia an ordinance requiring all owners of dogs to submit them to this mutilation. The ordinance was rendered more specific by a royal decree of February 20, 1767, establishing a regular corps of operators, whose duty consisted in visiting semi-annually all houses containing dogs, "worming" every animal, and furnishing the master thereof with a certificate to that effect. The edict prescribed, likewise, that every dog should be so treated before it had become six months old, and persons violating the law were condemned to pay a fine of fifty Prussian crowns, or, in default thereof, to suffer an imprisonment of one month. In 1786 a similar law prevailed in Hanover. This so-called worm was explained by some to be a vein, whose absence in a dog menaced by hydrophobia leads to engorgement of the throat and immediate asphyxia. It was regarded by Morgagni and Heydecker, after careful examination, as a spiral tendinous arrangement peculiar to the canine race, having some connection with the genio-hyo-glossus muscle, and serving to facilitate the act of lapping. Other authorities, however, deemed it to be the duct of the submaxillary gland, and others still maintained that it was merely the frenum linguæ. The English author, Fothergill, in his celebrated treatise on Hydrophobia, remarked that nothing was definitely settled relative to the utility of the operation, but that the whitish vermiform substance thus removed was nothing else, it might be presumed, than the canal forming a portion of the salivary apparatus, whose destruction might possibly exercise some influence upon the secretion, in diminishing, to a certain, extent, the liquid which transmits the virus.

The whole theory, however, was substantially demolished in 1786, in the very country where it was most in vogue. A rabid dog, near the village of Trieglitz, Prussia, bit a shepherd's dog, which was shortly afterward seized with rabies, and in turn communicated it to several cows. Both of these dogs were proved, by authentic certificates, to have undergone, when pups, the prescribed operation. The sanitary physicians of the district assembled to investigate the subject, and numerous instances were brought to their notice of hydrophobia having been imparted to both animals and men by dogs whose Tollwurms had been extirpated in the most approved manner. These facts led to the suppression of the corps of operators. Subsequently the authorities of the province of Detmold convoked a similar commission of investigation, the result of whose inquiries fully confirmed the conclusions previously reached.

This idea never obtained much credence among the English. Dr. Samuel Johnson spoke of the reputed worm in his expressive manner as "a substance—nobody knows what, extracted—nobody knows why."

According to a report of Dr. Armand to the Paris Academy of Sciences, the same practice still exists in Thrace, and it is described by Auzias Turenne, in the "Receuil de Médecine" for 1869, as then prevailing in Turkey and Moldo-Wallachia. Fleming states that it is quite common in Roumania, and Ramon de Sagra alludes to it as being popular in Spain. It prevails to some extent in our own country, especially in the South.

Columella, a contemporary of Pliny, in a work entitled "De Re Rustica," informs us that in his time it was believed among shepherds that, if, on the fortieth day after a pup's birth, the last bone of the tail be bitten off, the sinew will follow with it; after which the tail will cease growing, and the animal will remain secure from madness. This brutal mutilation is still sometimes practised by dog-fanciers, particularly in England, where the Royal Society for the Prevention of Cruelty to Animals have obtained several convictions against those resorting to it.

The ancients ascribed peculiar virtues to a variety of stone called *ammonis cornu*, which was supposed to possess the property of extracting the virus from wounds inflicted by mad dogs or venomous reptiles. Pliny alludes to it under the above name, and it has since received the appellation *ammonite*, both terms referring to its resemblance in shape to the horns which surrounded the head of Jupiter Ammon. It has also, in more modern times, been popularly known as the *mad-stone* and the *snake-stone*. Scientifically speaking, it is the fossil petrifaction of an extinct mollusk closely resembling the nautilus, having a spiral, symmetrical, and chambered shell, varying in size from that of a small bean to that of a large cart-wheel. In the East Indies and China it has for ages enjoyed the reputation mentioned.

In the fourth volume of the *Medical Repository*, an old journal published in this city in the beginning of the present century, may be found a communication from a Virginia gentleman, entitled "The Chinese Snake-stone, and its Operation as an Antidote to Poison." This remarkable stone, it appears, was brought from Bombay in 1740, and a portion of it subsequently came into the hands of Rev. Mr. Lewis Chaustien, of Frederick County, who employed it in cases of snake and dog bites. The writer describes how, his little daughter having been bitten by a mad dog, he was induced to carry her to Mr. Chaustien in order to obtain for her the benefit of his remedy. Having been informed that the stone, which was in three pieces, would adhere to no wound except one inflicted by a serpent or a mad dog, he tried the experiment of placing a piece upon two scratches on his child's body occasioned by a recent fall, but it immediately dropped off. On being applied, however, to the dog-bite, it at once took hold like a leech, and continued to stick for eight hours; and the other two pieces adhered successively an equal length of time before they fell off. They were then immersed in hot water, when, in a short time, a number of small bubbles began to rise, and a scum, like oil of a greenish-yellow color, soon covered the surface. The pieces were afterward dried in warm ashes. Mr. Chaustien exhibited a certificate which had accompanied the stone from Bombay, and which attested its efficacy in extracting venom from the bites of all poisonous animals. Another piece was in the possession of a Mr. Joseph Fredd, of Loudon County, Va. These wonderful stones doubtless still exist with virtues unimpaired—a profitable inheritance for those whose privilege it is to bestow their inestimable boon upon credulous humanity.

One of the most ancient measures employed in the case of a dog suspected of hydrophobia was, a prolonged sousing in cold water, which treatment, however, was not confined to animals, but was extended to persons whom they had bitten. Euripides, the Greek tragic poet, was said to have been thus preserved from hydrophobia. Even the celebrated and sagacious physician Celsus appears to have had confidence in the process, as he thus describes it: "The only remedy is to cast the patient unexpectedly into a pond, and, if he has no knowledge of swimming, to allow him to sink, in order that he may drink, and to raise and again depress him, so that, although unwillingly, he may be satiated with water."

In more modern days, Van Helmont gives the following quaint description of the same formidable method, as employed in his time: "There is a castle situated by the sea-side, four leagues from Ghent, which they call Cataracta. I saw a ship passing by it, and therein an old man, naked, bound with cords, having a weight on his feet; under his armpits he was encompassed with a girdle, wherewith he was bound to the sail-yard. I asked what they meant by that spectacle. One of the mariners said that the old man was an hydrophobid, or had the disease causing the fear of water, and had lately been bitten by a mad dog. I asked toward what part of the sea they wished to carry him. Did they intend his death? 'Nay, rather,' said the mariner, 'he shall presently return whole; and such is the blessing of the sea, that such a kind of madness it will presently cure.' I offered them some money to take me along with them as a companion and witness. When we had sailed about an Italian mile, the mariners did open a hole in the bottom, whereby the whole ship was almost sunk, even to the brim; indeed, they used the brine to recoct Spanish salt. And when, as that hole was now again exactly shut, two men, withdrawing the end of the sail-yard, lifted up the top thereof, and bore the old man on high; but thence they let him down headlong into the sea; and he was under the water about the space of a *miserere*, whom afterward they twice more plunged, about the space of an *angelical salutation.* But they then placed him on a smooth vessel, with his back upward, covered with a short cloak. I did think that he was dead; but the mariners derided my fear, for, his bonds being loosened, he began to cast up all the brine which he had breathed in, and presently he revived. He was a cooper, of Ghent, and, being thenceforth freed from his madness, lived safe and sound. Also the mariners did relate that the Dutch, by a raw herring salted, applied to the bite of a mad dog for three days' space and renewed, do take away all fear of madness. When this has been neglected, at least by the beheld manner of plunging they are all cured."

Fleming states that in Syria, at the present day, when a person is affected with hydrophobia, he is confined in a dark room, great care being taken to keep him tranquil, and prevent his seeing any red-colored object; and, if he thus survives for a certain period, he is cast from an eminence into the sea. This treatment would appear almost as effectual as another plan once pursued with hydrophobic patients, viz., smothering them between feather-beds.

A mere enumeration of all the absurd devices and medicaments employed from time immemorial to prevent or cure hydrophobia, would fill many pages. Charms, incantations, amulets, and mysterious religious rites, have had a large share in such preservative measures. One of the more modern and most remarkable superstitions connected with this subject is the reputed cure of hydrophobia by a pilgrimage to the shrine of St. Hubert, in the Ardennes—a custom prevailing even now in Belgium, and dating back to the ninth century. According to the legend, the stole of St. Hubert, by which the miracle is accomplished, was brought from heaven by an angel, who presented it to the saint while he was praying at the tomb of St. Peter, in Rome. At the same time he received also a golden key from St. Peter, by which he became endowed with a special power over evil spirits. Van Helmont thus alludes to the miraculous powers of this vestment: "Our good Catholics, despairing of relief from the faculty, repair to St. Hubert, at whose shrine, by virtue of certain ceremonies, they are cured; but it is worthy of remark that, if these ceremonies are not strictly observed, the latent rabies immediately breaks out, and they become irrevocably hydrophobic. There is a vestment of St. Hubert's which is preserved in a chest secured by six locks, the keys of which are kept by the six different vergers. For these fourscore years past they have been continually cutting off pieces from this holy vestment; nevertheless, it remains to this day perfectly entire! Now, it is impossible that there should be any imposture in the case; for they have never been able to discover whether this miraculous robe be of linen, woolen, or of silk; consequently it cannot be annually renewed. They cut off a piece of the robe and incarnate a thread between the skin of the patient's forehead. Hence another miracle—for a person thus cured becomes possessed of a power to postpone the hydrophobia during forty days in any of his acquaintance who, after being bitten, may not have leisure immediately to visit St. Hubert; on the condition, however, that, if they exceed the forty days ever so little, without applying for a prorogation of the term, they go mad irrevocably."

A rubric of the regulations to be observed by the patients, in order that the miracle might succeed, was printed in 1671. It contained a long catalogue of ridiculous observances and ceremonies, all of which, however, were in the same year condemned by the Sorbonne as "superstitious." That this practice continues, notwithstanding the oracular declaration of that famous theological establishment, may be inferred from the following circumstance, related by M. Stanislaus Prioux, in his "Vie de Saint Hubert:" "At the time when rabies had spread the utmost terror over the greater portion of the northern countries (about two years ago, in 1851), I knew an old man at Brussels, who, in his youth, had undergone the ordeal prescribed by St. Hubert, and who yet carried on his forehead the precious cicatrix. He assured me he had saved the lives of several people by granting them delays, while others bitten at the same time by the mad animals died."

According to Fleming, who quotes from Dudley Costello's "Tour through the Valley of the Meuse," what are called "the keys of St. Hubert" consist of an iron heated red-hot, and applied to animals bitten by mad dogs. It appears never to have borne the form of a key; for, in the town of St. Hubert itself the amulet was an iron ring inserted in the wall of one of the houses in the principal street. It no longer exists, though the belief in the potency of St. Hubert is, among the peasantry, as strong as ever. In other places, where this saint is especially venerated, the form of the exorcising instrument in no way resembles the key given by St. Peter. At Liège, it is also an iron ring, and at Utrecht an iron cross.

Among people more or less uncivilized, there prevail some curious notions with regard to hydrophobia. In the mountainous districts of Roumania, where the disease is common among wolves and dogs, the peasantry believe that birds of prey, as eagles, hawks, vultures, etc., fall dead from an aërial elevation never reached by other creatures, and are devoured by wolves; these latter thus contract rabies, transmit it to the shepherd-dogs, and they in turn communicate it to cattle and human beings simply by infecting the atmosphere with emanations from their diseased bodies. According to Burton (in his "Pilgrimage to Medinah and Mecca"), the tribes of El-Hejaz—a district of Arabia on the Red Sea—imagine that a bit of meat falls from the sky and renders mad any person eating it. They also recognize the fact of the communicability of hydrophobia from dogs. Burton says: "I was assured by respectable persons that, when a man is bitten, they shut him up, with food, in a solitary chamber for four days, and, if, at the end of that time, he still howls like a dog, they expel the *ghul* (devil) from him by pouring over him boiling water mixed with ashes —a certain cure, I can readily believe."

Sir Samuel Baker, while exploring the Nile tributaries of Abyssinia in 1862, found rabies quite prevalent in those regions. He relates how he was one night disturbed by a tremendous tumult, and light filling the air, and yelping of dogs. He went out and ran toward a blazing hut. "As I approached, first one, and then another dog ran screaming from the flames, until a regular pack of about twenty scorched animals appeared in quick succession, all half mad with fright and fire. I was informed that hydrophobia was very prevalent in the country, and that the certain preventive from that frightful malady was to make all the dogs of the village pass through the fire. Accordingly, an old hut had been filled with straw and fired, after which each dog was brought by its owner and thrown into the flames."

Fleming, while quartered with the British Army of Occupation at Tien-tsin, near Peking, China, in 1861, was assured on the best authority that, in some portions of the Flowery Land, it is the universal belief that a man affected with hydrophobia is *enceinte*, and that he is so distressed, and ultimately perishes, because he cannot be delivered!

Closely connected with outbreaks of lupine rabies, of which we have authentic accounts as early as the thirteenth century, was the remarkable superstition of the middle ages termed *lycanthropia*—a belief that human beings were temporarily transformed into wolves (or "were-wolves" as they were called), in order to satisfy an unnatural craving for human blood. It is well known that the wolf, when rabid, exhibits a peculiar change of habit and character. It quits its customary haunts in the forest recesses, and displays no fear or hesitancy in entering towns and villages, where it boldly encounters dogs, men, and other creatures, attacking them furiously, biting and tearing them, and then continuing its dreadful course of destruction. Brera relates that at Crema, Italy, in 1804, a mad wolf descended from the mountains and bit not only a vast number of animals, but thirteen persons besides, of whom nine perished of hydrophobia. This peculiar audacity of the rabid wolf, and the fact that a human being suffering from the disease often imagines himself personally identified in some manner with the animal that bit him, were doubtless largely concerned in the maintenance of this superstition at a period when, as Lecky observes, the air was surcharged with the supernatural. But, in fact, this fable may be traced back to mythological ages, and the existence of the "were-wolf" has been attested by Herodotus, Pliny, Strabo, Virgil, Ovid, and other ancient authors. Most of us remember the story recounted in Ovid's "Metamorphoses," of Lycaon, King of Arcadia, who entertained Jupiter with human flesh, in order to prove his omniscience, and was punished by having all of his sons, save one, and himself, transformed into wolves:

> "In vain he attempted to speak; from that very instant
> His jaws were bespattered with foam, and he only thirsted
> For blood as he ranged among flocks and panted for slaughter."

There are probably few countries in the world where some form of this superstition has not existed, but it has raged especially in places infested with wolves—in the Jura, in Russia, in Ireland (where, according to Camden, the inhabitants of Ossory were said to become wolves every seven years), in the wooded districts of Germany, France, Italy, Greece, and Turkey—regions where lupine madness has been particularly prevalent. Olaus Magnus, a writer of the middle ages, relates that in Prussia, Livonia, and Lithuania, although the inhabitants suffered much from the ravages of wolves among their cattle, they regarded such inroads as of little consequence compared with the ferocious attacks of were-wolves. He says, "On the feast of the Nativity of Christ, at night, such a multitude of wolves transformed from men gathered together in a certain spot, arranged among themselves, and then spread to range with wondrous ferocity against human beings and those animals which are not wild." Fincelius informs us that, in 1542, there were such a great number of were-wolves about Constantinople that a special expedition was organized against them, and the sultan, accompanied by his guard, left the city and slew one hundred and fifty. A French judge, named Boguet, about the end of the sixteenth century, devoted himself especially to lycanthropes, of whom he burnt a multitude, and afterward wrote a treatise on the subject.

Among the stupid popular ideas prevailing at the present time with regard to a mad dog is the belief that persons, who may have been bitten by the animal a long time previously and when it was healthy, are in danger of developing hydrophobia upon its subsequent appearance in the dog. This notion would seem almost too ridiculous to mention, were it not so common, that a dog who bites a person maliciously is almost invariably killed, with the sole intention of rendering the human being secure from hydrophobia. A little reflection should convince those who entertain this foolish superstition, that, by killing the animal, they are depriving themselves of the only means of certainty as to its actual condition; for, if in the first vague stages of rabies, it must exhibit pronounced symptoms within a very few days, whereas, if it remain healthy, by no possibility can the person bitten suffer other consequences than those ensuing from an ordinary wound.

PHYSIOLOGICAL BASIS OF MENTAL CULTURE.[1]

By NATHAN ALLEN, M.D., LL.D.

IN the advancing knowledge of physiology it has been discovered that all mental culture should be based upon the brain—that education should be pursued in harmony with the laws of life and health, and that, where these are violated, the advantages of the former afford poor compensation. Formerly no attention, or scarcely any, was paid by school boards and teachers, in the matter of education, to the condition of the body or the development of the brain, and even at the present day very little is paid them, compared with what should be given to those great physical laws which underlie all mental culture. The lives of a multitude of children and youth are sacrificed every year in this Commonwealth by violating the laws of physiology and hygiene, through mistaken or wrong methods of mental training; besides, the constitution and health of a multitude of others are thus impaired or broken down for life. Nowhere else in society is a radical reform needed more than in our educational systems. Inasmuch as the laws of the body lie at the foundation of all proper culture, they should receive the first consideration. But, in educating the boy or girl, from the age of five to fifteen, how little attention is given to the growth and physical changes which necessarily occur at this most important period of life! The age of the child should be considered; the place of schooling, the hours of confinement and recreation, the number and kinds of studies, together with the modes of teaching, should all harmonize with physical laws—especially those of the brain.

The system or mode of treating, in education, all children as though their *organizations were precisely alike*, is based upon a false and unnatural theory. Great injury, in a variety of ways, results from this wrong treatment; in fact, injuries are thus inflicted upon the sensitive organizations and susceptible minds of young children, from which

[1] From "Medical Problems of the Day"—a Discourse before the Massachusetts Medical Society.

they never recover. That many of our most independent and clear-headed educators themselves express so much dissatisfaction with the working and results of our schools, affords evidence that something is wrong in the present system. As we contemplate the great improvements made in education for the last thirty or forty years, and are surprised that educators were content to tolerate the state of things then existing, so will the next generation, when still greater and more radical changes shall have been introduced, look back with astonishment at this generation, and wonder that it was so well satisfied with its own methods. When our educators become thoroughly convinced that physical development as a part of education is an absolute necessity—that a strict observance of the laws of physiology and hygiene is indispensable to the highest mental culture—then we shall have vital and radical changes in our educational system; then the brain will not be cultivated so much at the expense of the body, neither will the nervous temperament be so unduly developed in proportion to other parts of the system, now so often bringing on a train of neuralgic diseases which cannot easily be cured, and exposing the individual to the keenest and most intense suffering which all the advantages of mental culture fail, not unfrequently, to compensate.

The more this whole subject is investigated, the more reason we shall find for making allowances or some distinction in scholastic discipline with reference to the differences in organization of children, and for adapting the hours of confinement and recreation, the ventilation and temperature of school-rooms, the number and kinds of studies, the modes of teaching, etc., to the laws of the physical system. But another and still more important change must take place. Some time —may that time be not far distant!—there will be a correct and established system of *mental science*, based upon physiological laws; and, until this era arrives, the modes and methods of education must remain incomplete and unsatisfactory. The principles of this science, in the very nature of things, must rest upon a correct knowledge of the laws and functions of the brain; and, until these are correctly understood and reduced to a general system, all education must be more or less *partial*, *imperfect*, and *empirical*. While the old theories of metaphysicians are very generally discarded, they still have practically a powerful influence in directing and shaping our educational systems and institutions. In the selection and arrangement of studies very little attention is paid to the peculiar nature or operations of the various faculties of the mind, or the distinct laws that govern their development and uses. For illustration, instead of educing, drawing out and training, all the mental faculties in their natural order and in harmony, each in proportion to its nature or importance, the memory is almost the only faculty appealed to in every stage of education; and this is so crammed and so stuffed that frequently but little of the knowledge obtained can be used advantageously. Instead of developing the observing faculties by "object-teaching," appealing to the senses of sight and hearing, those two great avenues of knowledge, or giving much instruction *orally*, we require the scholar to spend most of his time in studying and poring over *books*, mere *books*. The mind is treated as a kind of general receptacle into which knowledge almost indiscriminately must be poured, yes, forced, without making that knowledge one's own, or creating that self-reliance which is indispensable to its proper use. In this way the brain does not work so naturally or healthily as it ought, and a vast amount of time, labor, and expense, is wasted—nay, worse than wasted. From this forced and unnatural process there often results not only a want of harmony and complete development of all parts of the brain, but an excessive development of the nervous temperament, and not unfrequently an irritability and morbidness which are hard to bear and difficult to overcome. And not unfrequently it ends in a permanent disease of the brain, or confinement in a lunatic asylum.

When we take a careful survey of the various discussions and diverse theories on this subject, considered metaphysically, and then compare them with the great improvements and discoveries in the physical sciences for the last fifty years bearing upon the same subject, the change or progress looks mainly in one direction, viz., that all true mental science must ultimately be based upon physiology. Here is a great work to be performed, and when accomplished it will constitute one of the greatest, most valuable, and most important achievements, that was ever wrought in the history of science. A vast amount of positive knowledge has already been accumulated on this subject, by various writers, but a great work, by way of analysis, observation, and induction, and of further discoveries as to the functions of the brain, remains to be completed. This work must be performed, in a great measure, by persons profoundly versed in the physical sciences; and no small proportion of it must come from the observations, labors, and contributions, of medical men.

THERMAL DEATH-POINT OF LIVING MATTER.[1]

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II.

ALTHOUGH it is doubtless true that the superior dryness of seeds does enable them to resist the influence of heat longer than moist eggs are able to do, and therefore also enables them apparently to resist for a brief period a temperature notably higher than would have proved fatal to them had they been in a moist state—it

[1] From author's advance sheets.

is altogether another question when we have to decide whether moist Bacteria or their germs are endowed with this seed-like property of developing after desiccation. To maintain his position, Spallanzani was compelled to assume that they did possess this potentiality. Modern science, however, on the basis of experiment, declares that they have no such property. We are told most unreservedly by Prof. Burdon-Sanderson,[1] not only that "the germinal particles of microzymes (Bacteria) are rendered inactive by thorough drying without the application of heat," that is, by mere exposure to air for two or three days at a temperature of 104° Fahr., but also that, "fully-formed Bacteria are deprived of their power of further development by thorough desiccation." Thus is the most important assumption made by Spallanzani swept away, and with it all the strength that his position may have appeared to possess. Neither he, nor any of his followers, can hope to save their germs from the full action of heat by assuming the preëxistence of a protective desiccation, when they are told, on the unquestionable authority of Prof. Sanderson, that such desiccation would be in itself destructive to them.

We are left, therefore, now face to face with only one other question. Has the progress of science, it may be asked, since the time of Spallanzani, in any way tended to strengthen the possibility that Bacteria-germs or any forms of living matter in the moist state can resist the destructive action of boiling water, even for two or three minutes? And to this question a negative answer may be unreservedly given, since the progress of science has shown, on the contrary, that such a supposition becomes more and more improbable in the light of all uncomplicated investigations bearing on the subject. To these results of modern research I must now call the reader's attention.

In the first place, the specific question with which we are more immediately concerned, as to the thermal death-point of Bacteria and their germs, has itself been answered by most decisive experiments. As the writer has elsewhere already shown,[2] all direct experimentation on this subject leads to the conclusion that Bacteria and their germs, whether visible or invisible, are killed by a brief exposure to a heat of 140° Fahr. in the moist state. Thus Dr. Sanderson's experiments having proved that the germs of these organisms are, as regards their ability to withstand desiccation, related to eggs rather than to seeds, the writer's own experiments tend to strengthen this resemblance by showing that these Bacteria-germs also (like the eggs with which Spallanzani experimented) are invariably killed at a temperature of about 140° Fahr.

Although, therefore, my experiments are not favorable to Spallanzani's assumptions, they are entirely in accordance with his experiments. The thermal death-point ascertained by him for the eggs of

[1] "Thirteenth Report of the Medical Officer of the Privy Council," p. 61.

[2] "Proceedings of Royal Society," 1873, No. 143, p. 224, and No. 145, p. 325.

Insects and of Batrachia, agrees almost exactly with that which I have established for Bacteria-germs, although at the time my own experiments were made I was unaware of these particular results obtained by Spallanzani.

Is there, then, any thing in this fact concerning Bacteria and their germs at all at variance with what we might have been led to expect from our knowledge about the capacity for resisting heat shown by other kinds of living matter? Here, again, a negative answer may be unreservedly given. The grounds for this opinion must, however, be set forth, and, in dealing with this important question, I will range what I have to say under the following heads: 1. The results obtained by many other investigators, working quite independently of one another, (and in many cases also without distinct reference to the Origin-of-Life question), all go to show that different kinds of living matter are killed when in the moist state at or below the temperature of 140° Fahr. 2. The only known exceptions to this rule are cases of a special kind differing altogether from those with which we are at present concerned. 3. Our knowledge concerning the thermal death-point of Living Organisms and of Living Matter is remarkably harmonious, and is in accordance therefore with what we know concerning the unity of living matter generally. 4. The assumptions entertained by some, in support of their notion that living matter unaccustomed to the influence of heat is able to resist the destructive action of boiling water, are of the most frivolous nature—alike unsupported by experiment and contradicted by all ordinary experience.

1. Liebig proved that sugar-yeast (*Torula cerevisiæ*) entirely lost its power of growth and germination at 140° Fahr. It has been ascertained by Tarnowski, after numerous experiments conducted, as Sachs says,[1] "with all possible precautions," that spores of Penicillium and other common fungi, also most closely related by nature to Bacteria, "entirely lost their power of germinating when heated in their own nourishing fluids" to a temperature of 131° Fahr. Again, it has been ascertained by Dr. Timothy Lewis[2] that the germs of tape-worms are invariably killed at the temperature of 131°, while Prof. Mantegazza has shown that the male reproductive particles of frogs are killed by exposure to the same heat. So far, therefore, concerning germs, in addition to what I have already mentioned about Spallanzani's observations upon the eggs of Insects and Batrachia. Turning now to adult organisms of different kinds or to their elemental parts, the following facts may be cited: Pouchet[3] found that all kinds of Ciliated Infusoria were certainly killed at 131° Fahr., and while confirming this observation the writer found that a brief exposure to this temperature

[1] "Lehrbuch der Botanik," third edition, p. 626.

[2] "Eighth Annual Report of the Sanitary Commissioners with the Government of India," 1871, p. 139.

[3] "Nouvelles Expériences," etc., 1864, p. 38.

always sufficed to kill Amœbæ, Monads, Euglenæ, Desmids, Rotifers, Nematoids, and other minute aquatic organisms. The writer did not try to ascertain what was the lowest temperature which would prove fatal to these organisms, though this has been done by other observers. Spallanzani, for instance, ascertained that Ciliated Infusoria, Water-fleas, Leeches, Nematoids, and other worm-like creatures, all perished at 107–113° Fahr.; while Max Schultze,[1] and Kühne,[2] in part working over the same ground, have quite recently fixed the limits for such organisms at temperatures varying between 104° and 113° Fahr. At these temperatures the protoplasm entering into the formation of such organisms as well as that of the tissue-elements of higher animals was not only killed, it became coagulated and assumed the condition named by Kühne "heat-rigidity." Both Max Schultze and Kühne also found that the protoplasm of plant-cells with which they experimented was always similarly killed and altered by a very brief exposure to a temperature of 118½° Fahr. as a maximum. All accurate new observations, therefore, go to prove that different kinds of living matter, whether in the form of germ or of developed organism, are killed by a brief exposure in the moist state to a temperature at or below 140° Fahr.

2. So far I have been referring to the influence of heat upon living matter when it is suddenly applied to an altogether unaccustomed extent. This is the mode of operation with which we are especially concerned, as, with the view to the interpretation of experiments on the Origin-of-Life question, we wish to know the effects of great heat upon organisms accustomed to ordinary atmospheric and aquatic temperatures. On the other hand, it should be pointed out that organisms have been found living in hot springs at temperatures very considerably above those I have just been quoting; although the very highest of the temperatures, under the influence of which living things have been reported as existing in thermal springs, is still a few degrees below the boiling-point of water. The various observations that have been made upon this subject have been collected and criticised with much care by Prof. Jeffries Wyman,[3] to whose paper I would refer the reader. The most remarkable instances of this kind, in which Confervæ, or allied organisms, have been met with—that is, the highest temperatures cited which are at all trustworthy—are thus summarized by Prof. Wyman: "The statements we have quoted," he says, "give satisfactory proof that different kinds of plants may live in water of various temperatures, as high as 168° Fahr., as observed by Dr. Hooker in Sorujkund; 174° as observed by Captain Strachey in Thibet; 185° as observed by Humboldt in La Trinchéra; 199° as observed by Dr.

[1] "Das Protoplasma," Leipsic, 1863, pp. 33, 46.

[2] "Untersuchung über das Protoplasma und die Contractilität," Leipsic, 1864, pp. 46, 103.

[3] *American Journal of Science and Arts*, vol. xliv., September, 1867.

Brewer in California; and 208° as observed by Descloizeaux in Iceland." As we have no grounds for criticising these observations, we are bound to look upon them, provisionally at least, as correct and taken with all due care, though it is only fair to add that both Max Schultze and Cohn appear to be not altogether satisfied with some statements of the same kind.[1] Such instances, if thoroughly accurate, may perhaps be taken as examples of the highest temperature which it is possible for living matter to endure, even where it has been inured to its influence in the most gradual manner. And the real point of view from which these facts should be regarded is, indeed, pointed out by Prof. Wyman when he says: "Having become adapted through a long series of years to their surroundings, such organisms may be supposed to live under circumstances the most favorable possible for sustaining life at a high temperature. It is a well-known physiological fact that living beings may be slowly transferred to new and widely different conditions without injury; but if the same change is suddenly made, they perish. In the experiments made in our laboratories, the change of conditions is relatively violent, and therefore liable to destroy life by its suddenness."

3. If we omit, therefore, the facts concerning the existence of living organisms in thermal springs which are altogether peculiar, and which lie outside the boundaries of our present inquiry, all that we know about the unaccustomed influence of high temperatures upon living things can easily be shown to be even more harmonious than it may at first glance appear. We have only to bear in mind two or three general principles in order to be able to harmonize the several experimental results arrived at with the now very generally admitted doctrine as to the oneness or generic resemblance existing between all forms of living matter. We must bear in mind, first of all, the consideration enforced by Spallanzani, that there are different grades of vitality, or, in other words, forms of living matter which exhibit more or less of the phenomena known as vital, and that of these forms those which exhibit the most active life are those which would be most easily killed by heat. Thus we should expect the latent "life" of the germ, egg, or seed, to be less easily extinguished than the more subtile, and, at the same time, more active life of the fully-developed tissue-element or organism; and we should also expect that the vegetal element or organism would, as a rule, be less readily killed than the more highly-vitalized animal element or organism. These principles, based upon the consideration of relative complexity of life, are, however, subject to the influence of a disturbing cause, since we must also take into account, in the case of animals, whether we have to do with the elements of a warm-blooded or a cold-blooded organism, owing to the fact that custom or habitual conditions tend to render the more active tissue-elements of warm-blooded animals better able to withstand the

[1] Max Schultze, "Das Protoplasma," Leipsic, 1863, p. 67.

influence of heat than similar elements of less highly vitalized cold-blooded animals. Keeping these considerations in view, therefore, we may see by the following figures how harmonious are the facts already ascertained:

TEMPERATURES AT WHICH DEATH OCCURS.

Simple aquatic organisms...................... (*Spallanzani, Max Schultze, and Kühne.*)	are killed at	104°–113° Fahr.
Tissue-elements of cold-blooded animal—Frog... (*Kühne.*)	"	" 104°
Tissue-elements of warm-blooded animal—Man.. (*Stricker and Kühne.*)	"	" 111°
Tissue-elements of Plants—Urtica, Tradescantia, and Vallisneria........................... (*Max Schultze and Kühne.*)	"	" 116½°–118½°
Eggs, Fungus-spores, and Bacteria-germs........ (*Spallanzani, Liebig, Tarnowski, and others.*)	"	" 122°–140°

So far as we can ascertain by really scientific methods, free from all obvious possibilities of misinterpretation, these are the temperatures which undoubtedly kill the different varieties of that common life-stuff known as Protoplasm—the "physical basis of life," as it has been termed by Prof. Huxley. That it should present this comparative unity in its behavior toward heat as well as to other physical agencies, is surely not in antagonism with the most generally-approved biological doctrines, of which Prof. Huxley has made himself the most celebrated exponent in this country. In his own forcible language he tells us as follows: "Beast and fowl, reptile and fish, mollusk, worm, and polype, are all composed of structural units of the same character, namely, masses of protoplasm with a nucleus. . . . What has been said of the animal world is no less true of plants. . . . Protoplasm simple or nucleated is the formal basis of all life. . . . Thus it becomes clear that all living powers are cognate, and all living forms are fundamentally of one character."[1]

4. I now turn to say a very few words concerning the general attitude and specific statements made by those who, wishing not to give in their adherence to the fact of the occurrence of "spontaneous generation," affect to believe that Bacteria-germs or other kinds of living matter can resist the influence of boiling water.

In the first place, it should be said that not one of these persons has striven to justify his position by scientific evidence bearing directly upon the death-point of Bacteria and their germs, while several of them have glaringly attempted to make good their position in the most unscientific manner, that is, by adducing experiments admitting of two interpretations as though they were instances only admitting of one, and then of these two possible interpretations selecting that

[1] "Lay Sermons," pp. 126–129.

which the experiments were not originally destined to illustrate, and which is, moreover, contradicted by other less equivocal evidence, as to the very existence of which those who adopt this course take care to say nothing. This is a kind of treason to Science of which I hope the future may prove less prolific than the past has been.

And, if we turn now to the specific statements made by those who profess to believe that Bacteria and their germs are able to resist the influence of boiling water, we discover in the first place that all who advance such suppositions find it convenient to pass unnoticed the several series of experiments by which it has been proved that Bacteria and their germs are uniformly killed by an exposure to 140° Fahr. for five minutes. My opponents find it most convenient to take no notice of these experiments, though no one has as yet attempted to dispute their cogency. They prefer to talk vaguely, as though these experiments had never been made, and to adduce various theoretical reasons whose validity they do not attempt to test experimentally. To do this, indeed, would be a vain attempt, because they must be aware that such suppositions as they advance are opposed to generally-accredited scientific doctrines, even if they have not already been specifically refuted.

The suppositions principally dwelt upon may be ranged under three categories:

(*a.*) It is assumed by some that the mere minuteness of the germs of Bacteria may serve to protect them from that destructive influence which heat exercises upon living matter generally.[1] This is an old objection entirely unsupported by facts, and those who dwell upon it may be reminded that it was unhesitatingly rejected by the former chief of their school, Spallanzani, who said, "Un raisonnement de cette sorte est absolument contraire à toutes les notions que nous avons du feu." They may be further reminded that the writer's own experiments absolutely meet this objection, since they refer to the death-point of invisible germs of Bacteria just as much as to the death-point of those which are visible.[2]

(*b.*) Others, without definitely committing themselves to the belief that Bacteria-germs can resist the destructive influence of boiling water when they are immersed in it, affect to believe that some germs may have escaped its influence by being "spurted" out of the fluid on to the sides of the glass when the process of boiling commenced. How any such germs could escape the moistening and destructive influence of the hot steam with which they would still be in contact

[1] Some of those who rely upon this supposed reason have resorted to direct attempts to ascertain the death-point of the germs of other organisms, although their results have been, in part, vitiated by the evaporation of the drop of fluid employed, so that the organisms were subsequently exposed to the higher degrees of heat in a *dry* state.

[2] *See* "Proceedings of Royal Society," 1873, No. 143, p. 227.

these reasoners do not say, though some of them are cautious about openly suggesting an antecedent and protective state of extreme desiccation in the face of Dr. Sanderson's experiments proving that this would be in itself destructive. The futility of this reasoning has, however, been completely demonstrated by the fact that organisms will occur just as freely under conditions where no such objection can be alleged, that is, when the vessel and its contents are heated by submergence in boiling water, after it has been hermetically sealed—a mode of heating that has been occasionally adopted by different experimenters since the time of Spallanzani.

(*c.*) The third objection raised is no less remarkable, owing to its being similarly brought forward as an unsupported supposition in the face of much other evidence testifying to its nullity. When the writer's earlier experiments were first recorded, the public was authoritatively told by Prof. Huxley that the results were unworthy of credence, because the fact that tons of meats and vegetables were annually preserved from putrefaction by a very similar process was in itself the strongest evidence that he had in some manner deceived himself. It was never suggested or thought of, therefore, at this time, that such moist meats and vegetables were incapable of being heated through, even when pounds of them were aggregated together. It was, in fact, implicitly said that they could be so heated, and the fact of the preservation of the meats and vegetables was itself deemed to be the best evidence that all germs contained in their interior had been killed. Now that the writer has demonstrated to unbelievers, and when others have ascertained for themselves, that organisms are to be met with and that putrefaction will occur within almost airless and hermetically-sealed flasks whose contents have been previously boiled, the tactics of these unbelievers are entirely changed. Forgetting altogether their previous objection upon which they relied so long as they doubted the writer's facts, they now advance the interpretation of his results, which must carry with it its own stultification to the minds of those who have not entirely forgotten their previous position. The writer's methods are declared to be faulty for not freeing his infusions from all particles, however minute and however soft. The oracles now shake their heads, and talk with apparent learning about "the protective influence of lumps." While heat was previously supposed to be capable of operating as a germ-killer through pots of meats and vegetables, and while it has been proved to act in the same way through the thick and dry envelopes of seeds, now a pea or a minute particle of cheese, even though smaller than a pin's head, is thought to exercise a "protective influence" over imaginary germs! Such puerilities may safely be left to die a natural death, though it may be as well to remind those who trust to them, that, although they do not put their notions to the test of direct experiment, others have, for certain practical reasons, had occasion to do so. Dr.

Timothy Lewis, who has been for some time in Calcutta, carrying on, in concert with Dr. D. Cunningham, important sanitary investigations, has, among other things, directed his attention to the vitality of tape-worm germs in cooked meat. He proved, first, that tape-worm germs are undoubtedly killed by exposure for five minutes to a temperature of 135°–140° Fahr.; and then, with a view of ascertaining also how far they would be likely to experience such a temperature in the ordinary process of meat-cooking, he made other important observations having considerable interest for us. Dr. Lewis found that when legs of mutton had been put into the boiler almost as soon as the water, their central temperature averaged 140° Fahr. by the time the water around them had reached the boiling-point, and that, after the water had boiled for five minutes, the internal temperature of the legs of mutton which had remained in the boiler had on an average reached 170°. This is a practical method of dealing with the question which those skeptical dreamers who talk of the "protective influence of lumps" would do well to imitate.

After this I may perhaps be deemed fully justified in quoting two very typical experiments for the consideration of those who stave off their belief in the occurrence of "spontaneous generation" either by relying upon insufficient reasons for doubting the influence of boiling water, or because of their following Pasteur, Cohn, and others, in supposing that certain peculiar Bacteria-germs are not killed except by a brief exposure to a heat of 227° or 230° Fahr. For, even if we could grant them these limits, of what avail would the concession be toward staving off the dreaded admission of the occurrence of "spontaneous generation," in the face of such experiments as those which follow?

Experiment I.—A strong infusion of turnip was rendered faintly alkaline by liquor potassæ, and to this a few separate muscular fibres of a codfish were added. Some of this mixture was introduced into a flask of nearly two ounces' capacity. Its neck was drawn out and afterward hermetically sealed by the blow-pipe flame, while the fluid within was boiling. When thus closed the flask was about half full of fluid. It was then introduced into a digester which was gradually heated, and afterward kept at a temperature of 270–275° Fahr., for twenty minutes, though it seems also well to point out that, if we include the time taken for the water of the digester (in which the closed flask was immersed) to attain this heat, and also again to cool down to 230° Fahr., this flask was exposed to temperatures above 230° Fahr. for one hour, as I myself carefully noted at the time. When withdrawn from the digester the closed flask was kept at a temperature of 70–80° Fahr. for eight weeks, and during part of this time it was exposed to the influence of direct sunlight. After it had been ascertained that the flask was free from all crack or fault, its neck was broken, in order that its contents might be examined. The reaction of the fluid was found to have become decidedly *acid*, and it had a sour though not fetid odor, as though a fermentative process had been taking place in the solution. The fluid was very slightly turbid, and there was a well-marked sediment consisting of reddish-brown fragments, and of a light flocculent deposit. On microscopical examination the fragments were found to be portions of altered muscular fibre, while the flocculent deposit was composed for the most part of granular aggregations of *Bacteria*. In the portions of fluid and of deposit which were examined, there were thousands of *Bacteria* of most diverse shapes and sizes, either separate or aggregated into flakes. There were also a large number of monilated chains, of various lengths, of a kind very frequently met with in abscesses and other situations, where pyæmia or low typhoid states of the system exist, in the human subject. There were, in addition, a large number of *Torula* corpuscles, as well as of brownish, nucleated, spore-like bodies, gradually increasing in size from mere specks, about $\frac{1}{30000}$th up to $\frac{1}{2500}$th of an inch in diameter. Lastly, there was a small quantity of a mycelial *Fungus* filament, bearing short lateral branches, most of which were capped by a single spore-like body.

Experiment II.—A strong infusion of common cress (*Lepidium sativum*), to which a few of the leaves and stalks of the plant were added, was inclosed in an hermetically-sealed flask in the same way, heated in the digester at the same time (and therefore to the same temperature), and was subsequently exposed to the influence of the same conditions as I have already mentioned in connection with the last experiment. This flask was, however, opened one week later—that is, at the close of the ninth week after it had been heated in the digester to 270–275° Fahr. Before breaking the neck of the flask, the inbending of the glass under the blow-pipe flame showed that it was still hermetically sealed. The reaction of the fluid was found to be distinctly acid, though there was no notable odor. The fluid itself was tolerably clear and free from scum, but there was a dirty-looking flocculent sediment at the bottom of the flask, among the *débris* of the cress. On microscopical examination (with a $\frac{1}{12}$th "immersion" objective) much altered chlorophyll existed, either dispersed or aggregated among the other granular matter of the sediment, and among some of this three minute and delicate *Protamœbæ* were seen, varying in form, and creeping with moderately rapid, slug-like movements. They contained no nucleus, and presented only a few granules in their interior. In the same drop of fluid, and also in others subsequently examined, more than a dozen very active *Monads* ($\frac{1}{4000}$th of an inch in diameter) were seen, each provided with a long, rapidly-moving lash by which neighboring granules were freely knocked about. There were many smaller motionless and tailless spherules of different sizes, whose body substance presented a similar appearance to that of the *Monads*—and of which they were, in all probability, earlier developmental forms. There were also several unjointed *Bac-*

teria, presenting most rapid progressive movements accompanied by quick axial rotations. Many *Torula* corpuscles and other *Fungus* "spores" also existed, as well as portions of a mycelial filament containing equal segments of colorless protoplasm within its thin investing membrane.

A drop of the fluid containing several of these active *Monads* was placed for about five minutes on a glass slip in a warm-water oven maintained at a temperature 140° Fahr. All the movements of the *Monads* ceased from this time, and they never afterward showed any signs of life.

These experiments are two of the most remarkable selected from several others in which even higher temperatures were originally had recourse to in order to free the fluids and flasks generally from any thing like a trace of living matter. Nothing, that has yet been alleged by way of objection to the admission of "spontaneous generation" as an every-day fact, at all affects such experiments as these. The shortest way out of the difficulty would therefore be to doubt the facts. I can assure the reader, however, that they are as true and just as reliable as those other results obtained when working with lower temperatures, which, though strongly disbelieved in at first, are now generally recognized as trustworthy. And, although these now accredited results abundantly suffice, in face of our present knowledge concerning the limits of vital resistance to heat, to establish the strongest probability of the occurrence of "spontaneous generation," yet such experiments as those which I have now recorded even still further confirm this view, since it becomes incredible that, while all known forms of living matter with which accurate experiment has been made inevitably perish at or about 140° Fahr., the particular examples of the same forms which appear within our sealed flasks have been able to survive a much longer exposure to 270°–275° Fahr. If this were true, then indeed would the cultivation of Science be a vain pursuit—"uniformity," in fact, must be postulated and granted, or Science with humbled and sorrowful crest must retire from the field.

A word or two must be said in conclusion with reference to the interpretation which should be attached to such experiments as those just recorded. And this subject cannot be better introduced than by means of the following extract from the already-quoted and valuable paper by Prof. Jeffries Wyman. He says: "There can therefore be no certainty of the existence of spontaneous generation in a given solution, until it can be shown that this has been freed of all living organisms which it contained at the beginning of the experiment, and kept free of all such from without during the progress of it. On the other hand, this kind of generation becomes probable, whenever it is made certain that Infusoria are generated in solutions in which the conditions just mentioned have been complied with. We say probable, because their appearance under such circumstances would not amount to a proof. The absolute proof of spontaneous generation must come from the formation of living organisms out of *inorganic* matter. If Infusoria are generated in solutions of organic matter, independently of spores or germs, the question may be fairly raised whether we do not begin the experiment with materials in which life already exists, even though this material is not in the form of distinct organisms." Now, these last few lines, as they at present stand, tend to convey to the reader very erroneous impressions, and yet I am aware that views of the same kind are very commonly expressed, and seem to exist in an inchoate or half-realized form in the minds of many distinguished persons. It is for this reason, and on account of the authority attaching to Prof. Wyman's statements, that I am induced to take notice of this particular passage in order to attempt its rectification.

In the first place, then, under the old term, "spontaneous generation," are included two processes quite distinct from one another—namely, Heterogenesis and Archebiosis. With regard to Heterogenesis, this is merely the opposite of Homogenesis: and the latter is the name for that mode of generation or reproduction among living things which is looked upon with most respect and which is most generally known. It is the process by which "like produces like," that is, where the offspring grow into beings like their parents. In Heterogenesis, on the other hand, we have the birth of dissimilar products, the beginning of a new branch from a "life-tree," in which the offspring have no tendency to assume the parental type. This occurs, for instance, where the protoplasmic matter of an animal or of a vegetal cell becomes modified and resolved into Bacteria. Here we have to do with the mere transformation of living matter. It can, therefore, only take place where living matter preëxists. And seeing that many, among whom I may especially mention Needham,[1] Pouchet, and Trécul, have, both now and formerly, understood by the phrase spontaneous generation merely such a process of metamorphoses of living matter as is implied by the term Heterogenesis, it is very misleading to say that "the absolute proof of spontaneous generation must come from the formation of living organisms out of inorganic matter."

It seems obvious, however, that, when Prof. Wyman wrote this passage, he, forgetting the more common acceptation of the phrase "spontaneous generation," must have used it in the same sense as I now employ the term Archebiosis—in the sense, that is, of life-origination. But, even taking it in this sense, how far, we may ask, is Prof. Wyman justified in saying that its proof "must come from the formation of living organisms out of inorganic matter?"

The statement is, in my opinion, one which cannot be logically entertained by a believer in the ordinary physical doctrines of life, and

[1] *See* "The Beginnings of Life," vol. i., pp. 246–252, and vol. ii., p. 181.

consequently should be professed by no consistent believer in Evolution. Those who do not assent to these doctrines would probably never be able to believe in Archebiosis at all—to the "vitalist" life is an immaterial principle specially created, and therefore our flask experiments terminating in the birth of new organisms, if they carried with them any convictions at all, would simply be regarded by him as proving the occurrence of Heterogenesis. This is the view to which a vitalist would be driven, if he had become convinced that no germs of Bacteria, or of such organisms as are found in our flasks, could have survived the preliminary process of heating. Such a vague sort of position is not open, however, to those who believe in the now generally-accepted physical doctrines of life. They are bound to recognize the undoubted distinction which exists between mere dead organic matter and that organic matter which displays the phenomena of life. They should no more think of calling a body "living" which could not be made to display the characteristics of life, than they would call a body "magnetic" when it would show none of the properties pertaining to magnetism. If they had learned, therefore, that living matter when exposed to heat of a certain intensity became lifeless matter, the process by which new living protoplasm comes into existence among this dead organic material would be, for them, as much an instance of its new independent origin as if the process had occurred in the midst of mere inorganic elements. The term Archebiosis is therefore applicable to the process that must take place in our ordinary flask experiments where we have to do with dead organic matter, just as it is also applicable to those more primordial combinations which first gave birth to living protoplasm. The continued occurrence of an independent elemental "origin" of living matter we are called upon to believe in at the present day, though the actual steps of the process by which it takes place are unfortunately as completely unknown to us as are the steps by which its "growth" occurs whether from organic or from inorganic materials.—*Contemporary Review.*

ADDRESS BEFORE THE AMERICAN ASSOCIATION.[1]

By Prof. JOSEPH LOVERING.

I.

Instruments in Physical Progress.

WHEN the States-General of France were assembled for the last time at Versailles, after a long interval of inactivity, and an inaugural address was pronounced by the Bishop of Nancy, Mirabeau

[1] Retiring Address before the American Association for the Advancement of Science, at the Hartford meeting, August 14, 1874, by the ex-president.

passed upon his performance the sweeping criticism that he had missed the grandest opportunity ever offered to man for saying something or holding his tongue. And, whenever this Association, comprising not only those who teach, but many who create science, assembles, as it now does, to listen to the address of its retiring president, if he is duly sensible of his responsibility, he would gladly avail himself of Mirabeau's alternative, either of being equal to the occasion or of being silent. But the rule of the Association, adopted in the original draft of the constitution at Philadelphia, and the example of my predecessors which I am unwilling to reverse, leave me no choice; and when I see around me, not the terrible monsters of the French Revolution, maddened by the miseries of a down-trodden country, but calm and high-minded lovers of truth, I feel sure of a just and generous criticism. Welcome, then, the precious opportunity, enjoyed by the president of this Association, of discussing some of the great themes of science before an audience which has for its nucleus the original investigators, discoverers, and inventors in the country, and which, like the sun, is surrounded by an extensive chromosphere only a little less brilliant than the central body by contrast; and let my earnest endeavor be not to abuse or waste the great privilege.

I am confronted on the very threshold of my address by the doubt whether it were better to beat out the little bit of golden thought, for which I have time and capacity, into a thin leaf which shall merely gild the whole vast surface of scientific investigation, even for a single year, or to condense it into a solid though minute globule, only big enough and bright enough to light up some narrow specialty. The general practice which prevails, of selecting a president alternately from the two principal sections into which the Association is divided, will justify me in paying my particular addresses to the physical sciences, knowing that the large and active department of Natural History will be properly treated in its turn by those most competent to do it. Not even the capacious mind of a Goethe, a Humboldt, a Whewell, or a Herbert Spencer, is large enough to give a decent shelter to all the subjects which come within the scope of this Association. At the same time I must say that I sympathize with the remarks made by President Hunt at Indianapolis, when he questioned the propriety of excluding geology from the ranks of the physical sciences; only I would give them a still wider significance. Physical science is distinguished from natural history not so much by its subjects as its methods. In my imagination, I can picture to myself all these subjects as being handled in the same masterly grasp of mechanics and mathematics by which the physical astronomer holds in his hands the history and the destiny of the solar system. What is only a dream or a fancy now may become a reality to the science of the future. Why, asked Cuvier, may not natural history some day have its Newton, to whom the laws of circulation of the sap and the blood will be only as the laws of Kepler? With such an indorser, I may venture to quote these words of a consummate mathematician without fear of their being cast aside by the naturalists as one of Bacon's Idols of the Tribe: "An intelligence which at any given instant should know all the forces by which Nature is urged, and the respective situations of the beings of which Nature is composed, if, moreover, it were sufficiently comprehensive to subject these data to calculation, would include in the same formula the movements of the largest bodies of the universe and those of the slightest atom. Nothing would be uncertain to such an intelligence, and the future, no less than the past, would be present to its eyes." The time has already come when a knowledge of physical laws and familiarity with the instruments of physical research are indispensable to the naturalist. I would not recommend that dissipation of intellectual energy which will make a man superficial in all the sciences but profound in none. But Helmholtz has established, by his own example, the possibility of being an eminent physiologist, and, at the same time, standing in the front rank of physicists and mathematicians. The restlessness of human inquiry will never be satisfied with knowing what things are, until it has also discovered how and why they are, and all the relations of space, time, matter, and force, in all the kingdoms of Nature, have been worked out with mathematical precision.

It is a happy circumstance in the history of science, that this vast mechanical problem did not rush upon the mind at once in all its crushing generality. The solar system, with a despotic sun at the centre, competent to overrule all insubordination among planets and comets, and check all eccentricities and jealousies, and so far isolated from neighboring systems as to fear nothing from foreign interferences and entangling alliances, presented a comparatively simple problem; and yet the skill and labor of many generations of mathematicians have not yet closed up the argument upon this first case. On the orbits of this domestic system they have been sharpening their tools for higher and more delicate work. The motions of binary stars have also been brought under dynamical laws, and partially subjected to the rule of gravitation, so far as the astronomer can judge from the best observations which he can make upon those remote objects. But when he launches out, with his instruments and his formulas, into clusters of stars, even those of greatest symmetry, he is wholly at sea, without chart or compass or light-house, and with no other illumination than that which comes from a prophetic demonstration in Newton's "Principia." The mathematician has here to treat, not with an unlimited monarchy, as in the solar system, but with a republic of equal stars, and the dynamical condition of the clusters is involved in all the obscurity of molecular mechanics; for it matters not whether the individual members of a system are atoms or worlds, if the intervening spaces have corresponding magnitudes. Even in astronomy, the inspiration of mechanics and the pride of mathematics, how trifling is the region which has been subjugated to the rigid rules of the exact sciences when compared with the immense territories which remain under the jurisdiction of natural history, and must be studied, if at all, by the methods of the naturalist, though with an inverted microscope!

If, now, we circumscribe our outlook by the line which marks where physical science ends and natural history begins, it will be possible to examine only a few of the salient points in the prospect before us; and what these are will depend upon the point of view which we select. Whewell presents the history of any science at each of its successive epochs as circulating around one powerful mind, which figures as the hero of the drama, and whatever immediately precedes or follows is only the prelude or the closing strain to the great movement. In the philosophy of Comte, every science passes through a theological and metaphysical crisis before it reaches the healthy condition of positive knowledge, and its whole history is written out by him in these three acts. With Buckle, the progress of science, without which there could be no history, is coincident with the advance in civilization; but the action begins with science, and the reaction only comes from external causes. All that science and civilization demand is perfect freedom of thought. The worst enemy of both is the protective spirit in church and state, the former telling men what they must believe, the latter what they must do.

Each of these views of scientific development may be true, but not to the exclusion of all others. Metaphysical blindness or theological prejudice may block the way of science or defame its fair name. It has been stated that six members of the ultra-clerical party at Versailles voted against the appropriation for securing observations of the approaching transit of Venus, because they did not believe in the Copernican system, and this, too, while the echoes of the celebration of the four-hundredth birthday of Copernicus are still resounding over the earth! So, also, circumstances, and even accidents, may shape the course of discovery; the happiest of all accidents, however, being the appearance on the stage of the discoverer himself.

The point of view which I have chosen for reviewing the close and advancing columns of the physical sciences is this: Are there any improvements in the weapons of attack, or have any additions been made to them? These are of two kinds: 1. Instruments for experiment, and 2. The logic of mathematics. These are the lighter and the heavier artillery in this peaceful service.

If we cast a hurried glance over that long period of experimental research which began with Galileo and ended with Davy, we recognize, as the chief instrumentalities by which physical science has been promoted, the telescope, the microscope, the pendulum, the balance, and the voltaic battery. It is not necessary for me to enlarge upon the strength and accuracy which the battery and the balance have given to chemistry, or on the stretch and precision of vision which the telescope and microscope have bestowed on astronomy and physics. These instruments, the veterans of many a hard-fought battle, science still enjoys; not superannuated by their long service, but continually growing in power and usefulness. The little opera-glass with which Galileo first lifted the veil from the skies and awoke the thunders of the Vatican, has blossomed out into the magnificent refractors of Cambridge, Chicago, and Washington. The little reflector with which Newton, by a happy mistake, expected to supplant the lens, has grown into the colossal telescopes of Herschel, Rosse, and the Melbourne Observatory. The spasmodic, momentary action of Davy's batteries, sufficient, however, to inaugurate a new era in chemistry, has been superseded by constant currents, which grumble not at ten hours a day. After lighting up the forelands of a continent during the night, they are fresh to work an ocean-telegraph the next morning. With all my wonder at this mysterious instrument, which serves so faithfully the cause of science and civilization, with renewed admiration of the microscope and the telescope, one of which transforms an invisible speck of matter into a universe, and the other collects the immensity of the heavens into a little celestial globe upon the retina of the eye, I must pause for a moment to eulogize that simplest and most modest of scientific tools, the pendulum.

With the eye of science Galileo saw in the leaning Campanile at Pisa, not a freak of architecture, but the opportunity of experimenting on the laws of falling bodies; and, in the adjacent cathedral where others admired the marble pavement or the vaulted roof, the columns, statues, and paintings, his attention was caught by the isochronous vibrations of the chandelier, which during the long centuries has never been absolutely at rest. When it is said that the pendulum has no rival as a standard of length except the metre, that it furnishes an exact measure of time, and that time is an indispensable element in the study of all motion, and also the most available means of obtaining longitude on the earth and right ascension in the heavens, a strong case has been made out for the practical and scientific usefulness of Galileo's discovery. During the long years of doubt in regard to the true figure of the earth, the pendulum maintained the cause of Newton in opposition to the erroneous reports of the geodesists, until Maupertuis, by a new measurement, flattened, as has been pithily said, the earth and the Cassinis at the same time. The shape, rotation, and density of the earth; the diminution of terrestrial gravity with an increase of distance from the centre; the local attractions of mountains, and secrets hidden below the surface of the planet, have been discovered or verified by the declarations of the pendulum, which, whether in motion or at rest, has never tired of serving science. And, in a wider sense, the pendulum has done for the electric and magnetic forces what, in its restricted meaning, it did for gravity. That which Borda failed of accomplishing in the measurement of arcs, the pendulum realizes in its measurement of time: it multiplies its observations, eliminates its own errors, strikes its own average, and presents to science the perfect result. In 1851 a crowd of spectators were assembled in the Pantheon of Paris to witness the first performance by the pendulum of the new part prepared for it by Foucault, in which, obedient to its own inertia, and indifferent to the earth's rotation, it preserves the parallelism of its motion—an experiment startling, though not wholly unanticipated, and which has made a circuit of the earth. The new contrivance of Zöllner promises to indicate changes in the direction of a force as accurately as the common pendulum measures intensity.

Let us now consider what the physicists of our own day, and their immediate predecessors, have added to their rich inheritance of instrumental means, remembering all the time that, however impressive from their novelty these additions may be, and however manifold their applications, they have only supplemented the experimental methods which have been described without supplanting them. For the most part, the later devices would be useless without the coöperation of the earlier ones.

An interesting event in the history of science, which must be known to many of you, has taken place during the current year. In 1824, Poggendorff began to edit the *Annalen der Chemie und der Physik*. Under his supervision 150 volumes have been issued, containing 8,850 distinct communications from 2,167 different authors, the 193 papers of H. Rose outnumbering those of any other contributor. The history of physical and chemical discovery during the last fifty years might be written out of the materials treasured up in this single journal. In recognition of the signal service which Poggendorff has hereby rendered to science, his friends assumed the editorship of one volume in 1874, which is called the Jubilee volume (Jubelband).

In 1826, Poggendorff described, in Volume VII. of his journal, a device of his own invention for observing with exceeding nicety the movements of a magnetized bar. A mirror was attached to the bar and moved with it. From this mirror a beam of light was reflected into a theodolite. This was the origin of the happy thought of amplifying a trifling motion by making the finger of a long and delicate ray of light serve as a weightless pointer. A few years later, this idea was embodied by the mathematician, Gauss, in an instrument which he called the magnetometer. Since that time it has been continually budding out in new applications, scientific and practical. I need only recall to your recollection the beautiful method of Lissajous for compounding the vibrations of tuning-forks, and tracing in golden lines the curves which are characteristic of different musical intervals and varied phases of vibration. A new chapter has been opened in mechanics for describing and explaining these strange and nameless curves; and, in acoustics, the ear has been dispossessed by the eye of what would seem to be its own by right divine, and it is no longer the best scientific judge of sounds. By new devices Koenig has translated time into space, and made visible the individual vibrations of the invisible air; and, in numerous ways, the mechanism of sound is as real to the eye as the sensation is to the ear.

With a bare allusion to the fact that every message which passes over the cable-telegraph is a tribute of indebtedness to the simple but comprehensive method of Poggendorff, I pass to two other cases of great difficulty and wide significance in which the same method has triumphed. I refer to the determination of the velocity of electricity and the velocity of light.

When Wheatstone devised and executed the ingenious experiment of producing three electrical sparks, not strictly at the same instant, but after the brief interval required by electricity to travel over one-quarter of a mile of copper wire, and then observing, not the sparks themselves, but their images, as seen in a mirror revolving with the prodigious velocity of 800 turns in a single second, and from the prolongation and relative displacement of these images deducing the velocity of electricity, the duration of the electrical light, and the duality in the direction of the transmitted disturbance, he delighted the brotherhood of science by the skill and boldness of his attempt, and astonished it by the extravagance of his results. For twenty years no one ventured to repeat the difficult experiment. When it was finally tried by Feddersen, and more recently by our own associate, Rood, the values which they assigned to the duration of the electrical light, and which could not be challenged, made still the wonder grow. So far as this mode of experimenting concerns the velocity of electricity, Wheatstone stands alone, and his estimate of this velocity (the largest known velocity in the universe unless we count in the velocity of gravitation) has never been brought to a second trial. Indirectly, it has been tested by some of the operations conducted upon land and ocean lines of telegraph. When the local times of two places are compared by means of electro-magnetic signals, sent alternately in opposite directions, the difference of longitude and the transmission-time of electricity can be disentangled from one another, by the strategy of mathematics, and the most probable value computed for each. The velocity which has been calculated from these longitude-campaigns falls far below that credited to Wheatstone. The apparent discrepancy is explained by a misinterpretation of Wheatstone's experiment. An experiment which proves that electricity runs through one-quarter of a mile of wire *at the rate* of 288,000 miles a second, does not justify the inference that it would move over 288,000 miles in one second. Anomalous as the case may be, electricity has no velocity in the ordinary sense. The transmission-time of the electrical disturbance is proportioned to the square of the distance to be traveled. Therefore, the velocity has no constant fixed value, but varies with the length of the journey. This law, which is deduced from the mathematical theory of Ohm, introduces order among the experiments, where, otherwise, there would be chaos. It is not surprising that Wheatstone and the readers whom he addressed were misled by the original facts. Few men who have rendered signal services to science, and who have finally reached the highest pinnacle of fame, have suffered more from poverty and neglect, and waited longer for a recognition of their merits, than the modest student of Nuremberg. The slender volume which will perpetuate his name was indeed published at Berlin in 1827, and antedates Wheatstone's experiments by seven years. But the book was treated with contempt by a minister of state, to whom Ohm presented a copy, at his University of Cologne, and was first brought to the notice of English readers in 1841, when an English translation of it was effected through the agency of the British Association, and the Copley medal was presented to Ohm by the Royal Society of London. As late as 1860, when the same work was rendered into French, the translator admits that the mathematical theory of Ohm on the galvanic circuit, the elements of which have since rapidly circulated in popular text-books, was almost unknown in France, that high seat of science. If the serene but steady light of mathematics had not been dimmed by the blaze of experimental successes, and the teachings of Ohm had been heeded sooner, the science of electricity would have been the gainer, and the men of science would have been saved the mortification of treating the electro-magnetic telegraph as an impracticability.

When Wheatstone was a candidate to fill a vacancy in the corresponding members of the French Institute, it was objected that he had only made a brilliant experiment, but had not discovered a new principle. Arago came to his rescue, and asserted that he had introduced a powerful and fertile method of experimentation which would be felt in other sciences besides electricity. The French physicist lost no time in devising means for making good these claims. If it could be proved experimentally that the velocity of light was greater in air than in water, a capital fact in the contending theories of light would be settled forever. Arago planned the experiment and pressed its feasibility upon the Academy of Sciences with all the power and eloquence of his nature. At last he roused two younger physicists to undertake what his growing infirmities prevented him from doing with his own hands. The result declared in favor of undulations, and a fatal blow was dealt to the corpuscular theory of light which had vexed science since the days of Newton. If Fizeau and Foucault drew their inspiration from Arago, they owed their success to nothing except their own skill in devising and executing. Having tried the temper of their steel on this easier problem, they were ready for the grand attack, which was, to measure the absolute velocity of light.

The instrumental arrangements of these two experimentalists agreed only in the part which each borrowed from Poggendorff; the details differed so widely as to give to whatever agreement might appear in their results the force of an irresistible argument for their accuracy. The velocity of light, as found by Fizeau in 1849 by the artificial eclipses which the teeth of his revolving wheel produced, exceeds by about six per cent. the velocity which Foucault obtained, in 1862, with the moving mirror. The arithmetical mean of the two values comes very close to the astronomer's estimate of the velocity of light. But this simple average is precluded unless it can be proved that the two experiments are entitled to equal weight. The internal evidence, expressed by what mathematicians call the probable error, manifested a decisive preference for Foucault's result, and it has met with general acceptance. The soundness of the scientific judgment in this case has been placed beyond all cavil by Cornu, who has recently repeated Fizeau's experiment, with additional precautions, and resolved the discord into a marvelous accord. Fizeau's experiment, in spite of the numerical defect, was hailed as one of the grandest triumphs of experimental skill. In 1856 he received the prize of 30,000 francs which the Emperor of France had founded, to be given for the work or the discovery which, in the opinion of the five academies of the Institute, has conferred the greatest honor and service upon the nation. Hitherto, it had been supposed that nothing short of an interstellar or an interplanetary space was a match for the enormous velocity of light. And yet one physicist, by using a distance of less than six miles, and another, without going outside of his laboratory, have discovered what astronomers had searched heaven and earth to find out.

By these capital experiments the science of optics has achieved its own independence. Let us see what they have done, at the same time, for astronomy. The sequences in the eclipses of Jupiter's moons are modified by the velocity of light. The aberration of starlight is a measure of the ratio between the velocity of light and the velocity of the earth. For nearly two centuries our knowledge of the velocity of light leaned upon one or the other of these relations. If the velocity of light can be known from experiment, the problem may be reversed and the distance of the sun given to the astronomer. As soon as it appeared that Foucault's estimate of the velocity of light fell short of the astronomical valuation by about three per cent., it was certain that either the experiment was in error, or the received aberration was too small, or the reputed distance of the sun was too large. An error of three per cent. in the experiment or in the aberration was inadmissible. But it was conceivable that the distance of the sun should be at fault, even to this extent. The popular announcement that Foucault had picked a flaw in the astronomer's work was not correct. Astronomers had always known what those who pinned their scientific faith on text-books did not expect—that the problem of finding the sun's distance was an exceedingly delicate case, and that an ominous cloud of uncertainty hung over their wisest conclusions. Whenever it is possible to interrogate Nature in more ways than one, Science is not satisfied with a single answer, nor with all the answers unless they agree. The transit of Venus, the parallax of Mars, and the tables of the moon, each can tell the sun's distance. But their testimony was contradictory, and neither one at all times repeated the same story. The question was, which to believe. Since 1824, when Encke published his exhaustive computations on the last transits of Venus, the distance which they assigned to the sun has been acquiesced in as the most probable. But the moon, as has been said, has always been a thorn in the sides of mathematicians. While practical and theoretical astronomers have been reducing its motions to stricter discipline, the suspicion has been steadily gaining strength in their minds that the distance adopted from the transits was too large. The effect of Foucault's experiment was, to intensify the doubt. The case of the twin transits of the last century, thought to have been closed forever by Encke, has recently been opened again by the astronomer Stone. When Venus has nearly entered upon the sun, the moment of interior contact is preluded by the formation of a slender ligature (called the black drop) between the nearest parts of the two disks—caused, perhaps, by irradiation. One observer has recorded the time when this ligature began, another the time when it was broken. In working up the observations of the last transits, both classes were not combined indiscriminately. Mr. Stone has reexamined the documents, classified differently the materials, and extracted from them two new and independent values for the sun's parallax. The reconciliation which he has suddenly brought about between the experiments of Cornu and Foucault, the motions of the moon, and the transits of Venus, is as perfect as it is surprising. Nevertheless, the approaching transits of Venus, the earliest of which is close upon us, will be welcomed, if not as the only possible way of solving a hard problem, at least for the confirmation which is demanded by a solution already reached; for able astronomers have dissented from the interpretation put upon the records by Stone. The minds of observers have been prepared for what their eyes are to see, in December, 1874, by the experimental rehearsal of the black drop, and the photographer's box will arrest the planet in the very act.

The consequences of Foucault's experiment, substantiated as it may be by the best astronomical evidence, are as far-reaching as the remotest stars and nebulæ. The sun's distance is the astronomer's metre, through which masses, diameters, and distances, are proportioned out to planets, comets, and stars. If the sun's distance is cut down by three per cent., there must be a general contraction in all the physical constants of the universe. The earth only is immediately exempt from this liability. But, if, as modern science teaches, the earth lives only by the triple radiation from the sun, then an earlier doom has been written for the earth also. Geology is no longer allowed to cut its garment from the past duration of unlimited extent. The numerical estimates of physical science, with a large margin of uncertainty, assign limits between which alone geology has free play. Whatever tends to reduce or enlarge those limits must be of interest to the geologist as well as to the astronomer.

This is the brilliant career, in electricity, optics, astronomy, and geology, of the little mirror, cradled in the laboratory of Poggendorff, and which has not yet seen its fiftieth birthday.

In making this exhibit of the instrumental appliances of modern physics, I will simply name the polariscope, the stereoscope, and the instruments in photography, and hurry on to the spectroscope.

The steps by which the spectroscope has attained its preëminent rank among the instruments of the physicist and the astronomer were taken at long intervals. A whole century intervened between Newton's experiments with the prism and Wollaston's improvement. The substitution of a long and narrow slit for the round hole in the window-shutter was enough to reveal the presence of the two boldest dark lines in the solar spectrum. Wollaston stood on the threshold of a rich development in science, but neither he nor his compeers were ready for it, and what he saw, novel as it was, attracted little attention. Spectrum analysis, in relation to light itself, began when Frauenhofer published, in 1817, in the memoirs of the Bavarian Academy, an account of his experiments on the direct and reflected rays of the sun, on starlight, and various artificial sources of light, dispersing the rays by prisms of fine Munich glass and then receiving them into a theodolite. Frauenhofer repeated some of his experiments in the presence of the younger Herschel, but for many years he had the field wholly to himself. A paper by Herschel on the colors of artificial flames acquires a new interest from what has been done more recently. Between 1830 and 1860, numerous physicists, among whom are the well-known names of Brewster, Miller, Wheatstone, Powell, Stokes, Gladstone, Becquerel, Masson, Van der Willigen, Plücker, and Angström, were at work upon the facts connected with the emission of light by incandescent bodies and its absorption by gases and vapors. As early as 1830, Simms had placed a lens in front of the prism, with the slit in the focus, and another lens behind the prism to form an image of the slit.

The first hint of that pregnant fact, the reversal of the bright spectrum-bands of flames, came from Foucault in 1849. His experiment was repeated at Paris, in 1850, in the presence of Sir William Thomson. It was reserved for a young physicist of Heidelberg, who was not born until seven years after Frauenhofer laid the foundations, to place the keystone upon the structure on which many hands had labored, by demonstrating, in 1860, the law which is the theoretical basis of the chemistry of the heavens. Kirchhoff, with admirable frankness, is careful to say that this law had been anticipated by others, especially by Angström and Balfour Stewart, although it had not been sharply stated or severely proved. It is a singular fact that the mechanical explanation of the law, as it has been expounded by Kirchhoff, Angström, and Stokes, was partially enunciated one hundred years ago by the mathematician Euler, when he said that every substance absorbs light of the special wave-length which corresponds to the vibration of its smallest particles. The 11th of July, 1861, will be ever memorable in the history of science as being the day on which Magnus read, before the Berlin Academy, Kirchhoff's memoir on the chemical constitution of the sun's atmosphere, and the existence in it of familiar substances found upon the earth. Speedily, spectroscopes were multiplied, modified, and improved, and became indispensable auxiliaries in the workshop, the laboratory, and the observatory. It is not necessary to enlarge upon what this instrument has done for common chemistry, in hunting out the minutest traces of common substances and detecting new ones. The physician, the physiologist, the zoölogist, the botanist, and the technologist, have shared with the chemist and the physicist the services of this powerful analyst. But it is the highest prerogative of the spectroscope to be able to make a chemical analysis of celestial bodies, upon the single condition that they give to it their light. Polarization can only say whether any portion of this light is reflected. The motions which the telescope uncovers may decide in favor of a central attraction, but it is silent as to the intensity of this attraction unless the moving body belongs to the solar system. The universality of a gravitation may be proved, but not the universality of the very gravitation which pervades our own system, except by an argument from analogy. We see that one star differs from another star in glory. But what the other differences or resemblances are we know not, without the spectroscope. Henceforth astronomy possesses a new instrument of discovery, and also a new tribunal to which all speculations about the sun and the stars, the aurora and the zodiacal light, the meteors and the comets, must be brought and by which they must be judged.

I leave it to the naturalists to assign a value to the alleged anticipations of Darwin by the geometer Maupertuis, who was said to have died just before he was going to make monkeys talk. The whims and conceit of Lord Monboddo are not worthy of notice. Lamarck began life as a soldier, was a meteorologist as far and as long as Napoleon would allow him to be; perhaps he was a botanist from choice, but he was made a zoölogist, in spite of himself, by the revolutionary Convention. He was as brave in science as in war; but he expected to *create* it, by a simple effort of thought. Having demolished the modern chemistry, he turned his iconoclastic zeal into natural history.

His philosophy of zoölogy was published a few years after the cosmogony of Laplace; in which the mathematician broaches the theory of evolution as a mechanical doctrine, capable of explaining certain characteristics of the solar system, about which the law of gravitation is silent. Whoever reads the stately chapters of Laplace, on the stability of the planets and the safeguards of the comets, will easily recognize expressions which are the mechanical equivalents of the principles of natural selection and the survival of the fittest. The elder Herschel hazarded the speculation that the clusters of stars and the nebulæ which his devouring telescope had picked up, by hundreds, on the verge of the visible heavens, were genuine suns assembled under the organizing power of gravitation; and that the varieties in size, shape, and texture, were produced by differences of age and distance. The imagination of Herschel and other astronomers has taken a loftier flight. To them many of the nebulæ are not clusters of stars, but unborn solar systems, waiting for that consolidation by which planets are evolved and a central sun is formed, and destined thus to repeat the cosmogony of the home system. Comte claims that he has raised the nebular hypothesis to the rank of positive science. He supposes the stupendous enginery of evolution to be reversed. He follows, with his mathematics, the expanding sun backward into chaos, until it has absorbed into its bosom even the first-born among the planets, and finds, at every stage, numerical confirmation of what Laplace threw out as a plausible conjecture. As Mr. Mill and other writers of note have accepted this authority, it should be understood that Comte has never published the data or the process of his computations. By whatever other inspiration he arrived at his conclusion, he was not brought to it by his mathematics. He has said all that is necessary to show that he ignored all the difficulties of the problem, and dodged the only solution that could give satisfaction. The cosmogony of Laplace, with all its fascination, must be excluded from exact mechanics and remanded back to its original place in natural history, by the side of the more general nebular hypothesis of Herschel. All other cosmogonies which poetry or science have invented are childish in comparison with this; and no one would desire to banish it from science altogether, until it is disproved or displaced by something better. Instead of *deciding*, it must *share* the fate of the all-embracing cosmical speculation of Halley. How uncertain that fate is we may be taught by the frequency with which the preponderance of evidence has shifted from one side to the other, during the last fifty years. The irresolvability of many of the nebulæ, by powerful telescopes, led Herschel to espouse the cause of a diffuse primeval matter, out of which worlds were fashioned. No wonder that, in particular cases, the negative evidence was sometimes turned into positive evidence on the other side, by improvements in telescopes. Although every nebula which deserted from the nebular hypothesis strengthened the suspicion that the remaining irresolvability was purely optical, a sufficient amount of negative evidence would probably have always existed to create more than a doubt in the minds of many astronomers. On the discovery of spectrum analysis, observers rallied around it, in the hope of finding an escape from the dilemma; and this new hope has not been disappointed. The continuous spectra of some nebulæ prove them to be suns, enveloped in more or less of atmosphere. The broken spectra of other nebulæ show that they are in the condition of an incandescent gas. The classification which the spectroscope makes of the nebulæ corresponds so well with their telescopic appearance as to justify the confidence which one class of astronomers had in their way of deciding on the truth of the nebular hypothesis. While the spectroscope has manifested varieties of material, color, temperature, and consolidation in nebulæ and stars, both single and composite, beyond any thing which the perfected telescope could ever have revealed, it has at the same time found enough of earth in all of them to make man feel at home anywhere in the visible universe. The fact that certain well-known substances on this planet pass current everywhere in Nature, leads irresistibly to the conclusion that all the specimens came originally from the same mint. It is the legitimate office of science to reduce the more complex to the simple; to explain, if possible, the existing state of matter by an anterior state. The nebular hypothesis, which attempts to do this, no longer starts from a conjecture but a reality, viz., the existence of diffused incandescent vapor; and science will hold on to it, until a better theory of mechanical development is found.

An interesting question, which has waited thousands of years even to be asked, and may wait still longer for an all-sufficient answer, relates to the motion of what were once called the fixed stars. If numbers count for any thing, this is the grandest problem which can be presented to the mind of the astronomer. The argument from probabilities, which reposes on a substantial mathematical foundation, is loud in affirming some kind of motion, and repudiates the notion of absolute rest. We must place the stars outside the pale of science, and where no process of reasoning can reach them, or we must suppose that they subscribe to the universal law of all matter which we know, and exert attractive or repulsive forces upon each other. There may be one solitary body, or more probably an ideal point of space, the centre of gravity of the material universe, around which there is equilibrium, but everywhere else there must be motion. Though distance may reduce the effect of each one of the forces to a minimum, in the aggregate their influence will not be insignificant. The sun must share the common lot of the stars unless we repeat the folly of ancestral science, at which we now smile, and transfer the throne of the heaven of matter from the earth to the centre of our own little system. If the sun move, a new order of parallactic motion springs up in sidereal astronomy. The process of elimination requires the mathematician to calculate the direction and velocity of the motion of the sun which will leave behind it the smallest unexplained residuum; and this remainder is the motion of the stars themselves. The delicacy of the problem lies in the minuteness of the quantities to be observed, and in the assumptions which must be made in regard to the distances of the stars, only a few of which have been positively computed from parallax. However, a result has been reached, highly probable in the sun's case, but which can be converted into absolute values for other stars only so fast as their individual distances are discovered. Here, again, physics and chemistry, with the spectroscope in hand, have come to the aid of astronomy and geometry. Should it appear that the conclusions from spectrum analysis must be questioned, the attempt was brave, and even a defeat would be honorable.

In 1675 a Danish astronomer observed the novel fact that the frequency in the eclipses of Jupiter's satellites fluctuated with the motion of the planet to or from the earth. He hit upon a happy explanation, viz., that the swift light takes more or less time to telegraph the astronomical news across the omnipresent lines of force. This early observation is the *avant-coureur* of a host of others which have slowly followed in close array. That of a blind musician comes next. He noticed, in 1835, that the pitch of a steam-whistle, on the Lowell Railroad, fell suddenly as the locomotive passed him. Unfortunately, Munroe's observation was never published, although he sought and found an explanation of what was then a strange fact. In this case, the whistle sends the message, the waves of sound transmit it, and the ear is the register; but the changing distance modifies the time. In 1842, Doppler, of Prague, was led, by theoretical considerations, to formulate the proposition, now known in science as Doppler's principle: that the color of light and the pitch of sound, as they tell upon the senses, are changed by the relative velocity of the observer and the origin of the disturbance. In 1845, Buy Ballot made experiments upon the railroads in the Netherlands, and Scott Russell repeated them on English railroads, which confirmed the theory in the case of sound. In the application of the theory to color, few astronomers will be willing to follow Doppler in all his extravagances.

If it be true, theoretically, that the relative velocity of light, the wave-length of transmission, and the period of oscillation in the ether, are altered by the relative motion of the observer and the place from which the undulation starts, it is obvious that all other velocities have but a small chance in competition with the velocity of light, and that slight changes of color, if physically real as Doppler supposed, would fail of being recognized even by the eye of a painter. To interpose the spectroscope, and observe the change of refrangibility by the displacement of the sharp lines of the spectrum, was a lucky escape from this embarrassment. After Huggins had tried his hand at this new method, with a small telescope, upon the brightest of all the stars, he was supplied by the Royal Society of London with a larger instrument to pursue the investigation. The results of his spectroscopic inquiry into the motions of many stars have been published. Where these results have conflicted with the foregone conclusions of astronomy, Huggins has not hesitated to arraign the accuracy of astronomical data and methods. I have freely admitted the delicacy and difficulty of the geometrical process. The spectroscopic analysis, when applied to the same problem, walks upon slippery ground and must take heed lest it also fall. The alleged displacement is a nice quantity, and instrumental sources of error have been pointed out which may explain away the whole of it. I lay no stress upon the large difference between Vogel and Huggins in the *quantity* of motion which spectrum analysis ascribes to Sirius, inasmuch as the direction of the motion is the same. We do not yet know all the elements which the earth contains. The spectroscope has already added four to the number. There is reason to think that the stars, though having some substances in common with the earth and sun, are not without their peculiarities. The lines in the stellar spectra may be out of position, not because they are the displaced lines of sodium, magnesium, and hydrogen, but in consequence of novelties in the gaseous atmospheres of the stars. Still, there will be a presumption, perhaps a probability, in favor of Huggins's deduction, if it rests on a sound basis of theory. If there is any weakness in the physical and mathematical foundation of his argument, gratifying as it is to the imagination and the aspirations of science, the whole superstructure must fall.

THE EARLY STUDY OF GEOGRAPHY.[1]

By Major WILSON.

BEFORE concluding this portion of my address, I would draw your attention to the appliances used in the minor schools of this country for teaching geography, as they would seem to need some improvement. The appliances to which I allude are models or relief maps, wall maps, atlases, and globes. The use of models as a means of conveying geographical instruction has been too much neglected in our schools. If any one considers the difficulty a pupil has in understanding the drawing of a steam-engine, and the ease with which he grasps the meaning of the working model, and how from studying the model and comparing it with the drawing he gradually learns to comprehend the latter, he will see that a model of ground may be used in

[1] From the Opening Address of the President of the Geographical Section of the British Association.

a similar manner to teach the reading of a map of the same area. Relief maps of large areas on a small scale have their uses, but they are unsuitable for educational purposes on account of the manner in which heights must be exaggerated to make them appear at all; this objection, however, does not apply to models of limited areas on a sufficient scale, which always give a truthful and effective representation of the ground. One reason why models have not been more used has been their cost, but the means of constructing them with ease, rapidity, and at slight expense, are quickly accumulating as the six-inch contoured sheets of the Ordnance Survey are published. Instruction in geography should begin at home; and I would suggest that, as the six-inch survey progresses, each decent school throughout the country should be provided with a model and a map of the district in which it is situated. If this were done, the pupils would soon learn to read the model, and, having once succeeded in doing this, it would not be long before they were able to understand the conventional manner in which topographical features are represented on a plane surface, and acquire the power of reading not only the map of their own neighborhood, but any map which was placed before them. In our wall maps I think we have been too much inclined to pay attention to the boundaries of countries, and to neglect the general features of the ground. It is difficult to say whether the maps have followed the teachers or the teachers the maps, but I fear instruction in physical geography too often comes after that in political geography, instead of a knowledge of the latter being based on a knowledge of the physical features of the earth. My meaning may perhaps be explained by reference to a wall map probably well known to every one, that of Palestine, which frequently disfigures rather than ornaments the walls of our schoolrooms. In this map there are usually deep shades of red, yellow, and green, to distinguish the districts of Judea, Samaria, and Galilee, and perhaps another color for the Trans-Jordanic region, with a number of Bible names inserted on the surface, while the natural features are quite subordinate, and sometimes not even indicated. There is perhaps no book that bears the impress of the country in which it was written so strongly as the Bible; but it is quite impossible for a teacher to enable his pupils to realize what that country is with the maps at present at his disposal. The first object of a wall map should be to show the geographical features of countries, not their boundaries, and for this purpose details should be omitted, and the grander features have special attention paid to them. In school atlases the same fault may be traced, physical features being too often made subordinate to political divisions; and there is also, in many cases, a tendency to overcrowd the maps with a multitude of names which only serve to confuse the pupil and divert his attention from the main points. The use of globes in our schools should be encouraged as much as possible, as there are many physical phenomena which cannot well be explained without them, and they offer far better means of conveying a knowledge of the relative positions of the various countries, seas, etc., than any maps. The great expense of globes has hitherto prevented their very general use, but some experiments are at present being made with a view to lessening the cost of the construction, which it is hoped may be successful. I cannot pass from this subject without alluding to that class of maps which gives life to the large volumes of statistics which are accumulating with such rapidity. On the Continent these maps are employed to an extent unknown in this country, both for purposes of reference and education, and they convey their information in a simple and effective manner.

THE TRANSIT OF VENUS.

By Prof. S. P. LANGLEY,

OF THE ALLEGHANY OBSERVATORY.

ON the 8th day of the present month, at a little before nine in the evening of our time, the planet Venus will be first seen entering upon the face of the sun, from that side of the earth on which it is then day, and to observe the event astronomers will have made their way from all the principal countries of the civilized world. The spectacle in itself offers nothing that is imposing; to the naked eye, indeed, nothing of it will be visible, and all that the best telescope can discern will be a small, black, circular spot moving across the upper part of the solar disk, during some four and a half hours. The interest of the occasion, as all know, lies in the rare opportunity it offers for obtaining the sun's distance from the earth; but, as it is not so well understood why this distance is wanted, why it has not been found before, and what Venus has to do with determining it now, it is proposed here to attempt to answer such questions, as fully as it can be done in general and untechnical terms, and in a single article.

The exact object to be obtained can be better understood after considering what we know about the relations of the sun and planets, and what we have yet to learn. We know already, then, with almost entire exactness, the *relative* distances from the sun of every planet (the earth included), so that, if we wished to make a map of the solar system, on which the position of each member should be laid down with great precision, we have already all the means at hand to do it. Let us suppose such a map to be drawn, in which circles around a central point represent the planetary orbits. Then the planets being ranged in a line from the sun, and the distance of Venus from it being let us say five inches, that of the earth will be seven, and that of

Mars over ten, whence we observe that Venus is our nearest neighbor, and her distance from the sun two and a half times ours from her.

As round numbers are given only for simplicity, and as we could in fact draw such a map, with the actual elliptic orbits, in which no error would exist which a microscope could detect, it may be asked, "What more can be wanted?"

But there is a most important want unsupplied: our map has no *scale*, and we do not know how much an inch on it represents in actual distance. Our case, then, is like that of a person with an accurate chart of his country before him, from which he wants to find his distance from the capital. If it have no scale attached, or an erroneous one (and the latter is our own case), he cannot measure a single distance upon it.

If, however, he can ascertain the actual number of miles between *any* two points of the map, he will plainly know what an inch on it stands for, and thus be able to construct the lacking scale; and so we, if we can measure the distance between *any* two primary planets, or between any one of them (such as the earth) and the sun, have got at the same time the means of determining *all* the dimensions of the solar system.

A determination of the distance of any remote object, which we can see but cannot reach, whether celestial or terrestrial, the sun or a mountain-top, requires that we should know either its size and the angle it fills to the eye, or else how much the direction in which we see it changes, as we change our own position by a known amount. Thus, in the latter case, a surveyor, who wishes to determine his distance from an inaccessible object of unknown size, sends an assistant to hold up a staff at the end of a line measured on the ground by a chain. First he notes, with an instrument for the purpose, the direction in which the object is seen as compared with that of the staff, and then, the assistant and observer changing places, the latter notes again the direction from the second point of view, and this will enable him to calculate the distance desired. That first found by direct measurement with the chain is called the "base-line," and it ought to be considerable when the object is far away, since in that case its direction will not, evidently, be much altered, without a corresponding alteration in the observer's position. This difference of direction, caused by a changed point of view, is called by astronomers *parallax;* nearly the only professional term with which the reader need be troubled, but one which should be clearly understood.

The principle involved in the method is probably familiar to him already, but it is here recalled, to point out how its application must be modified in finding the distance of the sun. As the earth sweeps round that far-distant controller of her path, we can send no messenger in advance along our orbit to distinguish the place we shall move to later; we can leave no mark behind to denote the point in the void of space the earth has quitted. Our motion round the sun is therefore no help in finding its distance, and we may, in fact, for the sake of simplicity in illustration, treat the earth as standing still in its orbit, since the essential difficulty is thus nowise heightened. This difficulty, arising from the want of a proper base-line, is similar in degree and kind to that a surveyor would labor under, if he were called on to measure the distance of an object of unknown size at least half a mile away, without moving from his place. Success under such circumstances may well seem, not so much difficult as impossible; yet this is a fair simile of the apparent impracticability of measuring the distance of the sun without stepping beyond the limits of our little earth, a body so small by comparison with the sun's remoteness that, to an observer at that distance, a three-cent piece, held one hundred and fifty yards from the eye, would completely cover our globe and hide it from his view.

Within such narrow bounds we must work, or not work at all, and the reader, if he have not, from what he has just read, gained a definite conception of the principle on which all such distance measurement rests, may find aid in a very simple experiment. If any small object, such as a pencil, be held in front of the eyes as near as it can be conveniently seen, we may easily note the point on the opposite side of the room which it appears to cover, as viewed first by the right eye and then by the left. Though itself unmoved, it will appear to shift its place on the wall, when the latter is distant, in a notable degree, owing both to the difference of direction under which either eye views it, and the remoteness of the background, and the amount of this shifting will diminish progressively as it is carried directly away from the eyes, owing to its being now seen more nearly in the same direction by both, and to its approach to the wall. The change of *direction* is due to the distance from the eyes only, but, this being constant, the amount of its displacement on the wall is due only to the distance of the latter, as is easily proved by walking toward it.

The distance of the wall might conceivably be reckoned without going to it, by preparing tables which should show how this distance was proportioned to the apparent motion of the pencil on it, since one of these things evidently depends on the other, or which should tell the distance of the pencil, by the difference of direction under which we saw it. Such are the trigonometrical tables in common use, which give the distance when this change of direction and place is known. But this change as viewed by one eye or the other is the *parallax* of the pencil, the known distance between the eyes being a little "baseline," which plays the same part as the surveyor's longer one; and now, if we suppose ourselves in possession of tables which give the distance of any object, directly its parallax is known, we may substitute the earth for the head, two observers as far apart on it as they can get for the eyes, the sun's face for the wall, and Venus for the pencil, with a better idea of the way in which her coming between us and the sun will help to find how far off it is.

By the sun's horizontal parallax is meant that particular amount of change in its direction which would be noted by our two observers if they were half the diameter of the earth apart (as in Fig. 1, where the observer at *A* sees *V* in the direction *A B*, the one at *C* in the direction *C D*, and where the difference of these directions is *A V C*, the angle under which the earth's radius would be seen from *V*). At the

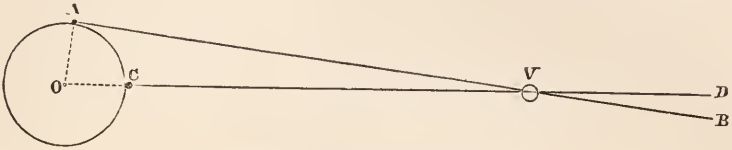

Fig. 1.—Horizontal Parallax.

risk of needless repetition, the reader is again asked to keep in mind that, finding an object's distance and finding its parallax are convertible terms: that when the latter is large it is easily got, and implies a short distance; that when small, it is found with difficulty, and implies great distance, and that the solar horizontal parallax is almost immeasurably small—less, whatever it is, than an angle of 9.″, or than that which would be filled by a human hair over five feet from the eye. It was an error of one-thirtieth part of this last—an error less, that is, than a literal hair's-breadth *seen fifty yards off*—which caused the mistake of 3,000,000 miles, now known to have been made in measuring the sun's distance in 1769; and, if the reader has heard such a mistake cited to the discredit of astronomy, he is now in a position to judge of the justice of the reproach. It may be added, in the words of Sir John Herschel: "Moreover, this error has been detected, and the correction applied, and the detection and correction have originated with the friends, and not the enemies, of science."

If we briefly review the history of human effort at this problem, we find it occupying the mind of the ancient philosophy as well as the modern. Ptolemy, following Hipparchus, estimated, by an unreliable method, the solar parallax at 3.′, or its distance at 1,210 semi-diameters of the earth; and this grossly erroneous value remained unimproved to the time of Kepler, with whose age modern astronomy begins. Kepler having, by life-long study, discovered a means of obtaining the proportionate distances of the planets from the sun, saw clearly that this led to a new *method* of finding its absolute distance; since, whatever it is, it stands in a known relation to that of Venus and Mars, either of which is easier found, owing to the comparative nearness of these planets, when in a line with the earth and sun. Venus, at this time, commonly passes above or below the sun, and in either case is lost in the surrounding brightness. Kepler left the suggestion, therefore, of the use of the latter's *transit*, for the benefit of the future generation in which it should occur. The parallax even of Mars turned out to be, with the means of that day, immeasurably small; but he reached from this the conclusion that the sun's still unknown distance was, at any rate, not less than 13,000,000 miles.

To see how it is that transits are so rare, we may consider the annexed diagram (Fig. 2), where the outer circle shows the orbit of the earth, and her positions in March, June, September, and December. The orbit of Venus, lying within this, would need to be represented by a ring, inclined to the plane in which the earth moves; that part of Venus's path nearest to the earth in March being above the surface of the paper, that nearest to our place in September being below it. If the planet passed in line with us and the sun between December and June, then it would appear to go above it; if between June and the following December, below it. There are two days in each year when we are crossing the line in which the planes of the two orbits cut each other. At these times the path of Venus, if it were a visible ring, would be seen like a slanting line on the sun; but, as the planet may be anywhere else *on* her path (as, for instance, at V_2), it is evidently only under a rare conjunction of favoring circumstances that we see her passage across the sun's face (at V_1), as a black circle on a brilliant background. This phenomenon, which can only, as appears from what has been said, occur in June and December, is known as the TRANSIT OF VENUS.

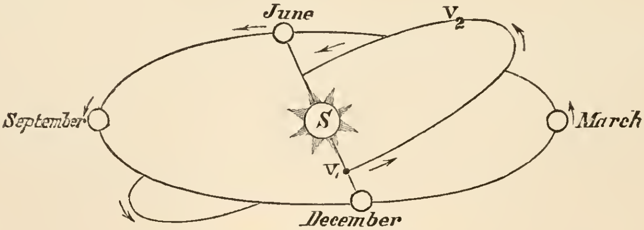

FIG. 2.—ORBITS OF VENUS AND THE EARTH.

Owing to the fact that Venus makes about thirteen revolutions in eight years, her transits frequently come in pairs eight years apart, though with an interval of over a century from one pair to the next; and thus transits have occurred in December, 1631 and 1639, in June, 1761 and 1769, and will occur in December, 1874 and 1882. That of 1631, though predicted by Kepler, passed unobserved; that of 1639 was the first known to have been seen by any one, and the circumstances of this epoch in the history of our subject deserve mention.

Jeremiah Horrocks, a young man, devoted to astronomical studies, though without counsel or support, had found from his own computations that a transit was likely to occur, though none had been looked for by others. He had time only to warn a friend of the expected event, then close at hand, and prepared himself to observe it, by forming, through a small aperture in a darkened room, an image of the sun upon a sheet of paper. This he watched continuously on the important day, a Sunday, till the time came for church. Though knowing that the opportunity, which would not occur again to any one then living, might pass in his absence, he left it for what he deemed a religious duty, and did not resume his observation till late in the afternoon. "At this time," said he, "an opening in the clouds, which rendered the sun distinctly visible, seemed as if Divine Providence encouraged my aspirations, when, *oh, most gratifying spectacle! the object of so many earnest wishes!* I perceived a new spot of unusual magnitude and perfectly round, which had just entered on the left limb of the sun." His friend had been equally fortunate, "and thus," says Mr. Grant, in his "History of Physical Astronomy," whence this account is taken, "did two young men, cultivating astronomy together in a state of complete seclusion in one of the northern counties of England, enjoy the privilege of witnessing a phenomenon which human eyes had never before beheld, and which no one was destined again to see till more than a hundred years had passed away." Horrocks attempted to obtain the sun's parallax, but without much success; good results from such observations requiring, as will be inferred from what has been said, to be made by a *pair* of observers removed from each other, nearly as far as the limits of the earth will allow.

In 1761 and 1769 astronomers were fully aware of the importance of the occasion. Special preparations were made by different European governments, especially for the latter year, when parties were sent, as now, to various portions of the illuminated hemisphere of the globe. Among the names of those employed are the familiar ones of Captain Cook, who made his first voyage to Tahiti for this purpose, and of Mason and Dixon, the surveyors of the "line" which bore their name, and which was once so frequently heard of in our own affairs.

One, who is less known, but whose singularly bad luck deserves sympathy, was Le Gentil. Sailing for Pondicherry, where he expected to observe the transit of 1761, he was unable to land, and got no other observations than such as could be made at sea. A voyage from Europe to the Indies in those days was something so formidable, that Le Gentil, who was resolved to see the transit of 1769, decided on waiting for it abroad through eight years of voluntary exile, but, by a cruelly hard fortune, when the long-expected day came, the sun was shut out from his view by clouds which had left the sky clear till the eventful occasion.

It is perhaps worth while to recall such a disappointment, to remind us that all the skill, means, and labor, which have gone to fit out the expeditions now absent, are equally liable to frustration by causes beyond human control; a contingency very remote, however, as affecting the entirety of the observers, and from which it is to be heartily hoped all will be exempted.

The results of the transit of 1769 were rendered uncertain, to some extent, by a curious attendant phenomenon called "the black drop," consisting in an apparent clinging of the planet to the limb, to which it is seemingly attached by a black ligament. The exact cause of this illusion is not quite agreed on, but there can be little doubt that it is in part a product of bad definition and inferior telescopes, and, as such, need be expected to give less trouble in our present observations of the times when the planet is really in contact with the edge. It may, however, cause an error of some seconds in noting the time, and in this particular seconds are all-important. Encke, who discussed these results, found from them that the parallax was 8.″56, a value always known to be questionable; but whence the sun's distance of "95,000,000 miles," which found a place in our school-books, was derived.

Within a few years past, it has become certain, by evidence from various quarters, that this is too much. Till toward the close of the last century, astronomers had no other means of finding the sun's distance than by observations on Venus and Mars; though, from those of the latter planet, indeed, a much closer approximation to the solar parallax than Kepler's value had long been obtained. Chiefly during the present century, other methods have been added, of which the most remarkable is that due to the French academician, Foucault.

Though the speed of the earth in its orbit, and that of light, were both unknown, yet the ratio of these two velocities had long been ascertained. From the assumed distance of the sun above given (95,000,000 miles), it was evidently possible to tell the circumference of the earth's orbit, and thence to say how many miles it went in a year, or a second, and, by a simple multiplication, a value for the velocity of light was obtained; since, as has just been said, the latter velocity bore a known proportion to the former. In this way, the value of 192,000 miles per second for the speed of light was found—a quantity which, being derived from an assumed distance of the sun, could not, of course, be used in turn to determine it. When, however, Foucault actually *measured* the velocity of light by a direct physical experiment, it became possible, by a reversal of the above process, to say how far the earth moved in a second; whence we learn how far it moves in a year, or, in other words, the length of its annual path; whence, again, the distance across it and the sun's distance obviously follow, the latter being thus found to be 92,260,000 miles, instead of 95,000,000.

From a discussion of all the different methods, Prof. Newcomb has concluded that the solar parallax cannot be far from 8″.85; while Mr. Stone, from a rediscussion of the results of the transit of 1769, believes that it is nearer 8″.91. The first value corresponds to a distance of 92,380,000 miles, the second to one of 91,730,000. It follows that we have heretofore made an error of about three per cent. in estimating the distances, and about ten per cent. in estimating the masses of the solar system. Neither authority regards his result as more than approximative, Prof. Newcomb, for instance, considering that his own may, as likely as not, be over a hundred thousand miles from the truth.

We get no idea from these large-sounding numbers of the all but inconceivable minuteness of the error of observation which would cause them; and such a measure of uncertainty, far from casting any discredit on the exactness of modern astronomy, is an evidence of its surprising advance toward absolute truth. Modern astronomy began with the age of Kepler; but, while the angle which represents the error in the parallax Kepler found, would correspond to that filled by the width of one of the pages of this magazine at a distance of 2,000 feet from the eye, the error now admitted as probable by Prof. Newcomb is represented by a less angle than that filled at the same distance by the same leaf turned *edgewise.*

Now that we have considered the delicacy of the measurements which have already been made, we are prepared to appreciate the task of those who, on the 8th of this month, are about to try to better them, and to examine the principles underlying the methods which will be actually used in the trial. To do this, we may, perhaps, here recur to a former illustration. If we suppose a person looking at a remote object—let us say a lighted window—from a distance which is quite half a mile, the distance between his eyes bears nearly the same relation to that of the light, that the distance between any two stations practically usable on the earth does to that of the sun. Accordingly, the difficulty of obtaining the sun's parallax, without moving from off the earth, is the same in degree that the observer would experience in measuring the distance of the light without moving from his place, and by means of the small virtual change of his point of view, obtained by looking at it with either eye; and it is under such all but insuperably hard conditions that astronomers will actually be working this month.

To see how Venus comes to their aid, we may represent her motion by a car moving at a uniform rate on a circular track, between the light and the observer. If the car pass across the light from left to right (as Venus crosses the sun), it will of course cut off the observer's view of the left side of the window from the left eye first, and, if the motion be slow enough, we may suppose him to note the exact time before the sight of the same point by the right eye is intercepted.

If he know from previous watching how long it takes the car to make its whole circuit of 360°, he knows from his watch, by an obviously simple computation, just what part of a degree it went over in passing, or in its shadow's passing, from one eye to the other; the angle, in other words, that the distance between his eyes would appear under, *as seen from the light.* But this is the parallax of the light, and it gives him its distance at once (that between the eyes—the base-line—being known).

This suggests the principle of a method of obtaining the sun's parallax, on which the English astronomers will largely rely.

For, neglecting matters of detail, and supposing Venus to pass centrally across the sun, since she completes her revolution of 360° in 225 days, nearly, we find, on dividing 360° by the number of minutes in that period, that in one minute she moves through an arc of 4.″, and dividing 360° by the number of minutes in our year, that the earth moves through 2″.46 in the same time. Hence, as Venus is gaining 1″.54 every minute, the case is the same as though the earth stood still, and the shadow of Venus (could she throw one so far) passed over the earth at that rate *as seen from the sun.*

Suppose an observer on the left or eastern side of the globe had his view of part of the left side of the sun intercepted by the interior planet at nine o'clock, and one placed opposite the centre of the globe (at half the earth's diameter west of the first), five and three-quarter minutes later, then, since $5\frac{3}{4}$ times 1″.54 is 8″.85, this angle 8″.85 represents the difference of directions in which the sun would be seen by the two observers, or, what is the same thing, the angle the earth's semi-diameter would fill to an eye at the sun. This is the solar parallax, and on reference to our tables we should find that such a difference of direction could only be caused by an object nearly 92,000,000 miles off. In practice, observers are not stationed at the extreme edge of the earth (as seen from the sun), because from such a station the sun itself would be seen in the horizon, where vision of it is obscured and rendered unsteady by the vapors of our atmosphere. Neither is it needful to place observers just half a diameter of the earth apart, since it is easy to allow for the effect of greater or less

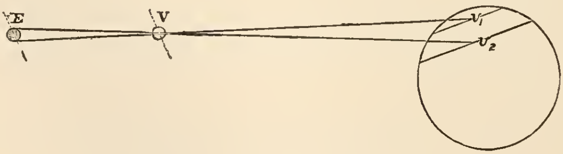

Fig. 3.—Showing the Displacement of Venus.

distance, and, in reality, the time would be longer than that supposed, because Venus's path lies aslant to the sun's edge, and it takes her longer to cross it. But it will, of course, be understood that such matters as these, and such complications as arise from the elliptical form of the orbits, the real inequality of the motion, the fact of the earth's being constantly turning and changing the observers' positions whether they will or no—that such things as these, and many more, need not occupy us here, except as they suggest how excessively intricate the actual details are with which the astronomer deals.

Quite another method might be used by our imaginary observer, if we suppose him to incline his head so that one eye is higher than the other, and to be able to see over the passing car. In this case, if the lower eye had the view of the lower part of the window hidden, the other, seeing *more* over the car, would see somewhat farther down—how much farther down would be easily calculated if the proportionate distances of the car from the eyes and the window were known. This suggests a very important method for actual use in the transit; for, if we now have two stations, one in the north or upper side of the earth (upper to us, that is), the other in the south or lower side, it is clear that the upper observer, seeing more *over* Venus, so to speak, will see it as it crosses the sun at V_2, nearer the centre than the observer who is in the south, and who sees it at V_1. (Fig. 3).

If the northern station is 6,000 miles higher than the other, since Venus is two and a half times as far from the sun as from us, it will appear to cross nearer the centre by two and a half times 6,000, or 15,000 miles. Knowing how large an angle this 15,000 miles on the sun's face fills, we have, as it will readily be seen, the knowledge of how large an angle a line any given part of its length (such as the earth's radius) would fill as seen from this distance.

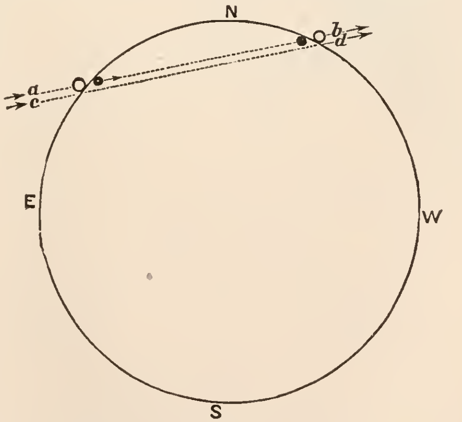

FIG 4.—PATH OF VENUS ACROSS THE SUN AS SEEN BY DIFFERENT OBSERVERS.

But it is immaterial whether we see such a length as the earth's radius from here, when it is supposed to be laid down on the sun, or from the sun when it is here. In either case we have got the same parallax and hence the same distance.

This apparent displacement of Venus will give us two chords of a circle (Fig. 3), the shorter one being her track to the southern observer, the longer to the northern. In Fig. 4, *a b* is her apparent path in the first case, *c d* in the second. This figure shows the direction of the planet's motion, and, with approximate truth, its apparent size as compared with the sun, and the degree of actual displacement. Its first appearance, touching the outside of the sun as at *a*, is what is called "first external contact." This is shortly followed by "first internal contact," when the planet has moved wholly on to the sun's face, and is just quitting the edge. After some four hours it touches the edge again ("second internal contact"), crosses it and disappears ("second external contact"). The external contacts have not hitherto been much relied on, but, now that with the spectroscope we can see the planet a little way off the sun, they can be better observed. The internal contacts are the important ones, and these have heretofore been rendered more or less uncertain, by the phenomenon called the "black drop," already referred to, as consisting in an optical illusion, by which the planet seems to cling to the limb and pull out of shape, like a drop of ink just about falling from the pen. (Fig. 5.)

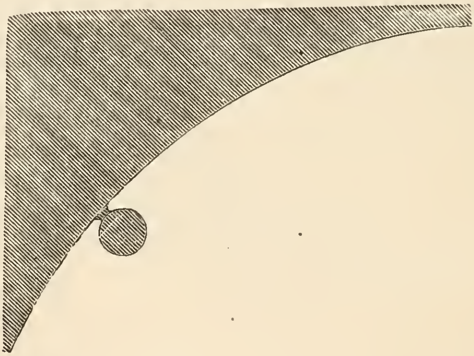

Fig. 5.—A Portion of the Sun at First Internal Contact of Venus, showing the "Black-Drop."

Since there is no actual track left to reckon the distance between the chords from, the northern and southern observers *time* the planet across, very accurately, and, from the times, the lengths of these chords, and hence the distance between them, may plainly be found, since we know just how long the planet would take to go over the sun's diameter. There is another way, by measuring the distance, from the sun's centre, of Venus at different stages of her progress, as seen by a pair or any number of pairs of observers; but probably best of all is photography, which is to be used by nearly every station, and which will give us almost any number of pictures (as many as 150 or 200 to a station), showing exactly how the planet looked from minute to minute to the photographer's lens—an observer which does not get flurried, is perfectly impartial, and whose observations take the form of an instantaneous but permanent record.

Preparations of the most elaborate kind have been made by the leading nations of the world for this event for years beforehand; and the side of our globe, turned sunward on the important day, will be occupied by over seventy astronomical stations. As an amicable interchange of results is to be counted on, the means for trying every method here alluded to, as well as others, will be of the amplest kind; and there is every reason to hope that they will give us a value of the sun's distance, accurate in proportion to the knowledge, energy, and skill, which have gone to furnish them.

From what has been already said, it must be abundantly plain that, unlike an eclipse of the sun, which is total over a very small area, the transit of Venus will be visible over a whole hemisphere of the earth—over more, in fact, since the rotation of our globe brings new countries into the sunlight during the hours the passage lasts, and some will see it begin who will not see it close; others see it close

FIG. 6.—EARTH, AS SEEN FROM THE SUN, DECEMBER 8TH, AT 9H. 10M., P. M., NEW YORK TIME. (First Internal Contact.)

FIG. 7.—EARTH, AS SEEN FROM THE SUN, DECEMBER 9TH. AT 1H. 13M., A. M., NEW YORK TIME. (Second Internal Contact.)

Names of American stations, as seen located in the above diagrams:

No. 1. Wladiwostock.
2. Pekin.
3. Nagasaki.
4. Hobarttown.

No. 5. Bluff Harbor.
6. Chatham Island.
7. Kerguelen "
8. Possession "

who do not see it begin. While the transit continues, wherever the sun can be seen, there Venus will be seen on it, with the exception of the few minutes of entry, when those on the extreme left of the earth will see her before the rest, and the corresponding time of exit.

We do not see the phenomena at all in the United States, because all America is on the night side of the earth at the time, a fact made plainer by the accompanying diagrams, showing the earth as it is poised in space, viewed from the sun; first at the beginning of the transit (to the whole earth), and again at its close, with the effects of the earth's rotation in the interval. These diagrams are made from those prepared by Mr. Proctor (to whose admirably lucid illustrations the writer is otherwise indebted), and by Mr. Hill, under the charge of Prof. Coffin, of our own "Nautical Almanac" office; and on them have been marked the eight stations occupied by American parties. The next transit, in December, 1882, will be visible, it may be observed, from beginning to end, in the United States.

On the whole, it will appear, from what has been stated, that a transit of Venus, though not the only means of determining the sun's distance, and not possessing the relative importance it once did, remains probably the best, as it is the best known, and, if it may be so called, the most classic method.

Judging from what appears to be the probable error of our best independent determinations of the solar parallax (those from Mars), and the presumption that the majority of astronomers regard those obtainable by modern methods from Venus as still better, it is no unreasonable anticipation that the probable error of the coming result will not exceed one-hundredth of a second. In other words, it may be expected to be at least an even wager that the error of angular measurement in the final result—made up, let us remember, from the independent results of observers working in distant parts of the globe—will not exceed that which would be represented by the breadth of a hair, seen at the distance of *one mile.* So slight is that error, which will seem so large when carried out in the enormous numbers which represent the distance of the sun, and those numbers still more inconceivable which represent his own distance from his brother stars.

In one of the most remarkable writings which have descended to us from ancient philosophy, the "Arenaria" of Archimedes, that geometer undertakes to show his contemporaries that it is in the power of number to reckon not only every grain of sand upon the sea-shore or even in the whole earth, but more than would fill a solid sphere extending beyond the sun; and, in the course of his demonstration, he describes to us how he attempted to find its diameter by measurements carried on with a staff and a rod, when the morning and evening mists rendered its light bearable to the eye. If the striking picture of this "Newton of the ancient world" gazing at the setting sun, to attempt, with such rude means, a portion of the task which remains unsolved after two thousand years, be recalled here, it is because it seems fittingly to remind us of the early steps of that ascent on which man's long effort has raised him to the power of questioning Nature with means of the wonderful exactness just described, and to remind us also how long human thought has rested on the great problem to which we hope this present month may bring an answer.

THE GREAT CONFLICT.[1]

By JOHN WILLIAM DRAPER, M. D., LL. D.

WHOEVER has had an opportunity of becoming acquainted with the mental condition of the intelligent classes in Europe and America, must have perceived that there is a great and rapidly-increasing departure from the public religious faith, and that, while among the more frank this divergence is not concealed, there is a far more extensive and far more dangerous secession, private and unacknowledged.

So wide-spread and so powerful is this secession, that it can neither be treated with contempt nor with punishment. It cannot be extinguished by derision, by vituperation, or by force. The time is rapidly approaching when it will give rise to serious political results.

Ecclesiastical spirit no longer inspires the policy of the world. Military fervor in behalf of faith has disappeared. Its only souvenirs are the marble effigies of crusading knights, reposing on their tombs in the silent crypts of churches.

That a crisis is impending is shown by the attitude of the great powers toward the papacy. The papacy represents the ideas and aspirations of two-thirds of the population of Europe. It insists on a political supremacy in accordance with its claims to a divine origin and mission, and a restoration of the mediæval order of things, loudly declaring that it will accept no reconciliation with modern civilization.

The antagonism we thus witness between Religion and Science is the continuation of a struggle that commenced when Christianity began to attain political power. A divine revelation must necessarily be intolerant of contradiction; it must repudiate all improvement in itself, and view with disdain that arising from the progressive intellectual development of man. But our opinions on every subject are continually liable to modification, from the irresistible advance of human knowledge.

Can we exaggerate the importance of a contention in which every thoughtful person must take part whether he will or not? In a matter so solemn as that of religion, all men, whose temporal interests are not involved in existing institutions, earnestly desire to find the truth. They seek information as to the subjects in dispute, and as to the conduct of the disputants.

The history of Science is not a mere record of isolated discoveries; it is a narrative of the conflict of two contending powers, the expansive force of the human intellect on one side, and the compression arising from traditionary faith and human interests on the other.

[1] Preface to the "History of the Conflict between Religion and Science," No. XII. of the "International Scientific Series," to be published shortly.

No one has hitherto treated the subject from this point of view. Yet from this point it presents itself to us as a living issue—in fact, as the most important of all living issues.

A few years ago, it was the politic and therefore the proper course to abstain from all allusion to this controversy, and to keep it as far as possible in the background. The tranquillity of society depends so much on the stability of its religious convictions, that no one can be justified in wantonly disturbing them. But faith is in its nature unchangeable, stationary; Science is in its nature progressive; and eventually a divergence between them, impossible to conceal, must take place. It then becomes the duty of those whose lives have made them familiar with both modes of thought, to present modestly, but firmly, their views; to compare the antagonistic pretensions calmly, impartially, philosophically. History shows that, if this be not done, social misfortunes, disastrous and enduring, will ensue. When the old mythological religion of Europe broke down under the weight of its own inconsistencies, neither the Roman emperors nor the philosophers of those times did any thing adequate for the guidance of public opinion. They left religious affairs to take their chance, and accordingly those affairs fell into the hands of ignorant and infuriated ecclesiastics, parasites, eunuchs, and slaves.

The intellectual night which settled on Europe, in consequence of that great neglect of duty, is passing away; we live in the daybreak of better things. Society is anxiously expecting light, to see in what direction it is drifting. It plainly discerns that the track along which the voyage of civilization has thus far been made, has been left; and that a new departure, on an unknown sea, has been taken.

Though deeply impressed with such thoughts, I should not have presumed to write this book, or to intrude on the public the ideas it presents, had I not made the facts with which it deals a subject of long and earnest meditation. And I have gathered a strong incentive to undertake this duty from the circumstance that a "History of the Intellectual Development of Europe," published by me several years ago, which has passed through many editions in America, and has been reprinted in numerous European languages, English, French, German, Russian, Polish, Servian, etc., is everywhere received with favor.

In collecting and arranging the materials for the volumes I published under the title of "A History of the American Civil War," a work of very great labor, I had become accustomed to the comparison of conflicting statements, the adjustment of conflicting claims. The approval with which that book has been received by the American public, a critical judge of the events considered, has inspired me with additional confidence. I had also devoted much attention to the experimental investigation of natural phenomena, and had published many well-known memoirs on such subjects. And perhaps no one can give himself to these pursuits, and spend a large part of his life in the public teaching of science, without partaking of that love of impartiality and truth which Philosophy incites. She inspires us with a desire to dedicate our days to the good of our race, so that in the fading light of life's evening we may not, on looking back, be forced to acknowledge how unsubstantial and useless are the objects that we have pursued.

Though I have spared no pains in the composition of this book, I am very sensible how unequal it is to the subject, to do justice to which a knowledge of science, history, theology, politics, is required; every page should be alive with intelligence and glistening with facts. But then I have remembered that this is only as it were the preface, or forerunner, of a body of literature, which the events and wants of our times will call forth. We have come to the brink of a great intellectual change. Much of the frivolous reading of the present will be supplanted by a thoughtful and austere literature, vivified by endangered interests, and made fervid by ecclesiastical passion.

What I have sought to do is, to present a clear and impartial statement of the views and acts of the two contending parties. In one sense I have tried to identify myself with each, so as to comprehend thoroughly their motives; but in another and higher sense I have endeavored to stand aloof, and relate with impartiality their actions.

I therefore trust that those, who may be disposed to criticise this book, will bear in mind that its object is not to advocate the views and pretensions of either party, but to explain clearly, and without shrinking, those of both. In the management of each chaper I have usually set forth the orthodox view first, and then followed it with that of its opponents.

In thus treating the subject it has not been necessary to pay much regard to more moderate or intermediate opinions, for, though they may be intrinsically of great value, in conflicts of this kind it is not with the moderates but with the extremists that the impartial reader is mainly concerned. Their movements determine the issue.

For this reason I have had little to say respecting the two great Christian confessions, the Protestant and Greek Churches. As to the latter, it has never, since the restoration of science, arrayed itself in opposition to the advancement of knowledge. On the contrary, it has always met it with welcome. It has observed a reverential attitude to truth, from whatever quarter it might come. Recognizing the apparent discrepancies between its interpretations of revealed truth and the discoveries of science, it has always expected that satisfactory explanations and reconciliations would ensue, and in this it has not been disappointed. It would have been well for modern civilization if the Roman Church had done the same.

In speaking of Christianity, reference is generally made to the Roman Church, partly because its adherents compose the majority of

Christendom, partly because its demands are the most pretentious, and partly because it has commonly sought to enforce those demands by the civil power. None of the Protestant Churches has ever occupied a position so imperious—none has ever had such wide-spread political influence. For the most part they have been averse to constraint, and except in very few instances their opposition has not passed beyond the exciting of theological odium.

As to Science, she has never sought to ally herself to civil power. She has never attempted to throw odium or inflict social ruin on any human being. She has never subjected any one to mental torment, physical torture, least of all to death, for the purpose of upholding or promoting her ideas. She presents herself unstained by cruelties and crimes. But in the Vatican—we have only to recall the Inquisition—the hands that are now raised in appeals to the Most Merciful are crimsoned. They have been steeped in blood!

There are two modes of historical composition, the artistic and the scientific. The former implies that men give origin to events; it therefore selects some prominent individual, pictures him under a fanciful form, and makes him the hero of a romance. The latter, insisting that human affairs present an unbroken chain, in which each fact is the offspring of some preceding fact, and the parent of some subsequent fact, declares that men do not control events, but that events control men. The former gives origin to compositions, which, however much they may interest or delight us, are but a grade above novels; the latter is austere, perhaps even repulsive, for it sternly impresses us with a conviction of the irresistible dominion of law, and the insignificance of human exertions. In a subject so solemn as that to which this book is devoted, the romantic and the popular are altogether out of place. He who presumes to treat of it must fix his eye steadfastly on that chain of destiny which universal history displays; he must turn with disdain from the phantom impostures of pontiffs and statesmen and kings.

If any thing were needed to show us the untrustworthiness of artistic historical compositions, our personal experience would furnish it. How often do our most intimate friends fail to perceive the real motives of our every-day actions; how frequently they misinterpret our intentions! If this be the case in what is passing before our eyes, may we not be satisfied that it is impossible to comprehend justly the doings of persons who lived many years ago, and whom we have never seen?

In selecting and arranging the topics now to be presented, I have been guided in part by "the Confession" of the late Vatican Council, and in part by the order of events in history. Not without interest will the reader remark that the subjects offer themselves to us now as they did to the old philosophers of Greece. We still deal with the same questions about which they disputed. What is God? What is the soul? What is the world? How is it governed? Have we any standard or criterion of truth? And the thoughtful reader will earnestly ask, "Are our solutions of these problems any better than theirs?"

The general argument of this book, then, is as follows:

I first direct attention to the origin of modern science as distinguished from ancient, by depending on observation, experiment, and mathematical discussion, instead of mere speculation, and shall show that it was a consequence of the Macedonian campaigns, which brought Asia and Europe into contact. A brief sketch of those campaigns, and of the Museum of Alexandria, illustrates its character.

Then with brevity I recall the well-known origin of Christianity, and show its advance to the attainment of imperial power, the transformation it underwent by its incorporation with paganism, the existing religion of the Roman Empire. A clear conception of its incompatibility with science caused it to suppress forcibly the Schools of Alexandria. It was constrained to this by the political necessities of its position.

The parties to the conflict thus placed, I next relate the story of their first open struggle; it is the first or Southern Reformation. The point in dispute had respect to the nature of God. It involved the rise of Mohammedanism. Its result was, that much of Asia and Africa, with the historic cities Jerusalem, Alexandria, and Carthage, were wrenched from Christendom, and the doctrine of the Unity of God established in the larger portion of what had been the Roman Empire.

This political event was followed by the restoration of science, the establishment of colleges, schools, libraries, throughout the dominions of the Arabians. Those conquerors, pressing forward rapidly in their intellectual development, rejected the anthropomorphic ideas of the nature of God remaining in their popular belief, and accepted other more philosophical ones, akin to those that had long previously been attained to in India. The result of this was a second conflict, that respecting the nature of the soul. Under the designation of Averroism, there came into prominence the theories of Emanation and Absorption. At the close of the middle ages the Inquisition succeeded in excluding those doctrines from Europe, and now the Vatican Council has formally and solemnly anathematized them.

Meantime, through the cultivation of astronomy, geography, and other sciences, correct views had been gained as to the position and relations of the earth, and as to the structure of the world; and since Religion, resting itself on what was assumed to be the proper interpretation of the Scriptures, insisted that the earth is the central and most important part of the universe, a third conflict broke out. In this Galileo led the way on the part of Science. Its issue was the overthrow of the Church on the question in dispute. Subsequently a subordinate controversy arose respecting the age of the world, the Church insisting that it is only about six thousand years old. In this she was again overthrown.

The light of history and of science had been gradually spreading over Europe. In the sixteenth century the prestige of Roman Christianity was greatly diminished by the intellectual reverses it had experienced, and also by its political and moral condition. It was clearly seen by many pious men that Religion was not accountable for the false position in which she was found, but that the misfortune was directly traceable to the alliance she had of old contracted with Roman paganism. The obvious remedy, therefore, was a return to primitive purity. Thus arose the fourth conflict, known to us as the Reformation—the second or Northern Reformation. The special form it assumed was a contest respecting the standard or criterion of truth, whether it is to be found in the Church or in the Bible. The determination of this involved a settlement of the rights of reason, or intellectual freedom. Luther, who is the conspicuous man of the epoch, carried into effect his intention with no inconsiderable success; and at the close of the struggle it was found that Northern Europe was lost to Roman Christianity.

We are now in the midst of a controversy respecting the mode of government of the world, whether it be by incessant divine intervention, or by the operation of primordial and unchangeable law. The intellectual movement of Christendom has reached that point which Arabism had attained to in the tenth and eleventh centuries; and doctrines which were then discussed are presenting themselves again for review; such are those of Evolution, Creation, Development.

Offered under these general titles, I think it will be found that all the essential points of this great controversy are included. By grouping under these comprehensive heads the facts to be considered, and dealing with each group separately, we shall doubtless acquire clear views of their inter-connection and their historical succession. I have treated of these conflicts as nearly as I conveniently could in their proper chronological order, and, for the sake of completeness, have added chapters on—An examination of what Latin Christianity has done for modern civilization; a corresponding examination of what Science has done; the attitude of Roman Christianity in the impending conflict, as defined by the Vatican Council.

The attention of many truth-seeking persons has been so exclusively given to the details of sectarian dissensions, that the long strife, to the history of which these pages are devoted, is popularly but little known. Having tried to keep steadfastly in view the determination to write this work in an impartial spirit, to speak with respect of the contending parties, but never to conceal the truth, I commit it to the considerate judgment of the thoughtful reader.

SKETCH OF DR. J. LAWRENCE SMITH.

WE give, this month, an excellent portrait of one of the most active and accomplished of our American scientists, one who has not only extended the boundaries of knowledge by his researches in the various fields of investigation to which he has devoted himself, but who has been a missionary of science to one of the old Oriental countries, and labored successfully to diffuse its benign influences among a semi-barbarous people.

J. Lawrence Smith was born December 16, 1818, near Charleston, South Carolina. His father, Benjamin Smith, was a Virginian, who had removed to South Carolina. The subject of this brief memoir received a classical education in the Charleston College, after which he was sent to the University of Virginia. At this institution he enjoyed facilities for the indulgence of his taste in the acquisition of knowledge in that department for which he had in early life shown a decided predilection—pure mathematics. In the later part of his academic career, he devoted himself to the higher branches of physics, mixed mathematics, and chemistry, pursuing the latter somewhat in the form of a recreation.

In determining a practical pursuit in life, young Smith selected civil-engineering as a profession, and, after devoting two years to the study of its various branches, in connection with geology and mining engineering, he was employed as one of the assistant engineers on the railroad projected at that time between Charleston and Cincinnati. This pursuit not proving congenial with his scientific tastes, he turned to the study of medicine, the college of the city of Charleston at that time possessing a corps of eminent medical teachers. After studying medicine three years, Dr. Smith was graduated by the Medical College of South Carolina, after which he went to Europe, where he devoted three more years to the study of medicine. But during all this time he continued his devotion to those departments which first commanded his scientific affections. He studied physiology under Flourens and Longet; chemistry under Orfila, Dumas, and Liebig; physics under Pouillet, Desprez, and Becquerel; mineralogy and geology under Elie de Beaumont and Dufrenoy.

Dr. Smith returned to America in 1844, having already begun to earn a reputation in original scientific researches, principally in connection with the fatty bodies. His paper on Spermaceti, in 1842, at once stamped his character as an experimental inquirer.

On his return to Charleston, Dr. Smith commenced the practice of medicine, and there delivered a course of lectures on toxicology. But the State of South Carolina, needing his services as assayer of the bullion that came into commerce from the gold-fields of Georgia, North and South Carolina, appointed him to that duty. At the same time he gave a great deal of attention to agricultural chemistry, for which he had acquired a great fondness in Liebig's laboratory, and to this were added researches in geology and mineralogy. Among the attractive features of the agricultural chemistry of his native State that early drew the attention of Dr. Smith, were the unrivaled marls on which the city of Charleston stands. These beds of fertilizers are from 110 to 310 feet deep, and are in what geologists call the Tertiary formation. They extend back more than 100 miles from Charleston. Dr. Smith was one of the first to ascertain the scientific character of this immense agricultural wealth. His paper on this subject, with the correspondence of Prof. Bailey, the great microscopist of the Military Academy of West Point, is one of much interest. He also pointed out the large amount of phosphate of lime in these marls, from which there are now obtained immense quantities of phosphatic nodules.

During these scientific labors, Prof. Smith made a valuable and thorough investigation into the meteorological conditions, character of soils, and culture, affecting the growth of cotton. The report on this subject was so valuable, that in 1846 President Buchanan appointed Prof. Smith, in response to a request of the Sultan of Turkey, to teach the Turkish agriculturists the proper method for successful management of cotton-culture in Asia Minor. On arriving in Turkey Prof. Smith was chagrined to find that an associate in the commission had induced the Turkish Government to undertake the culture of cotton near Constantinople. Prof. Smith was unwilling to associate his name with an enterprise which he felt satisfied would be a failure, and the event fully justified his judgment. Prof. Smith was on the eve of returning to America, when the Turkish Government tendered him an independent appointment, that of mining engineer, with most liberal provisions. This position he filled during four years, and he performed his duties with such signal success, that the Turkish Government heaped upon him the decorations of the empire, and very costly presents. The results of Prof. Smith's labors are a permanent advantage to the empire, and it has received ever since 1846, and continues to receive, large revenues from his discoveries of emery, chrome, ores, and coals, within the domain of Turkey. His papers on these subjects, read before learned societies, and published in the principal scientific journals of Europe and America, gave him a high position among scientific men. His labors in Asia Minor on the subject of emery, which he was the first to discover there, led to its discovery in America; and in Massachusetts and North Carolina a large industrial product of emery is now carried on. In the scientific journals of this country, the papers on emery and corundum recognize the successful researches of Prof. Smith as having done almost every thing for these commercial enterprises. These discoveries of emery in Asia Minor destroyed the rapacious monopoly of the article at Naxos, in the

Grecian Archipelago, increased the amount of emery used five or six fold, with a corresponding reduction in price. In many of the arts of life the free use of emery or corundum has become a necessity, but this free use of these articles would have been greatly retarded without a very material reduction in price.

While in the employment of the Sultan of Turkey, Prof. Smith investigated a great variety of Turkish resources, besides those directly within the purview of his appointment as mining engineer. His paper on the "Thermal Waters of Asia Minor" is one of extreme interest and great scientific value.

In 1851 Prof. Smith invented the inverted microscope, an important improvement; for, while it may do the work of any other microscope, there are very interesting fields of research which can be cultivated by no other instrument. Dr. Carpenter, in his work on "Physiology," bears strong testimony to its value.

After Prof. Smith's return from Turkey, his *Alma Mater*, the University of Virginia, elected him Professor of Chemistry, and, while discharging the duties of that chair, he, in connection with his able assistant, George J. Brush, at present one of the chief professors in the Sheffield School of Science, performed a much-needed work in revising the "Chemistry of American Minerals." A full account of these labors was given in the *American Journal of Science*, and subsequently in a valuable and interesting work containing the scientific researches of Prof. Smith, recently published by J. P. Morton & Co., in the city of Louisville.

After marrying, in Louisville, the daughter of the Hon. James Guthrie, Prof. Smith adopted that city as his home. He was elected, soon after settling in Louisville, to the chair of Chemistry in the Medical Department of the University of Louisville, a position which he held for a number of years. After resigning that chair, he took scientific charge of the gas-works of Louisville. He has a private laboratory where he spends several hours each day, and continues his devotion to original research.

Prof. Smith was one of the commissioners to the Paris Exposition of 1867, and made an able report on "The Progress and Condition of Several Departments of Industrial Chemistry." It is very nearly exhaustive of the important subjects to which it is devoted. Prof. Smith was again appointed commissioner to Vienna in 1873, and discharged his duties with his usual ability.

Prof. Smith's important original researches are no less than fifty in number, and his scientific reports are numerous, showing great activity and perseverance in cultivating the field he has chosen. Among the honors he has received is the highest that American science can confer, the presidency of the American Association for the Advancement of Science, to which he was elected in 1872.

CORRESPONDENCE.

RIVER HYDRAULICS.

To the Editor of The Popular Science Monthly:

IN the July number of The Popular Science Monthly, there is an article entitled "The Hydraulics of Great Rivers," said to have been mainly derived from an account, in the April number of the *Edinburgh Review*, of a book called "The Paraná, the Uruguay, and the La Plata Estuaries," by M. Révy, a member of the Institute of Civil Engineers of Vienna.

In that article there were so many statements calculated to give an erroneous impression to the reader, that it seemed to me some comment was called for. These statements I will examine in turn:

"At the point near Rosario, where the river is 4,787 feet wide, a series of measurements has been made by M. Révy, which constitutes the largest measurement of a river section yet effected. . . . The average depth was 47½ feet, and the greatest 72 feet, while the sectional area measured 184,858 feet."

In the "Report upon the Physics and Hydraulics of the Mississippi River," by Captain Humphreys and Lieutenant Abbot, of the Corps of Topographical Engineers, United States Army, published by Lippincott & Co., in 1861, by authority of the War Department, there are given the dimensions of 93 cross-sections of the Mississippi River, commencing at Columbus, Ky., and extending to Fort St. Philip, some 75 miles below the city of New Orleans. Two sections, one at Osceola, Ark., the other at Randolph, Tenn., measured by Lieutenant Abbot in 1858, are, respectively, 6,880 and 6,080 feet in width, 195,844 and 184,717 square feet in area, the maximum depths being 87 and 117 feet; while four of the other sections of the Mississippi exceed 243,000 square feet in area, which M. Révy gives as the measurement of the same Rosario section during the ordinary flood. The claim, therefore, of "the largest measurement of a river-section yet effected," is hardly a valid one. The language, "largest measurement yet effected," rather gives one the idea that it is a pretty difficult matter to measure the cross-section of a large river, whereas it is a comparatively simple operation. A sounding-party in a boat, and two observers at the extremities of a carefully-measured base-line on shore with theodolites taking simultaneous observations on the sounding-boat, are all that is necessary to determine the section with great accuracy.

To quote again: "While, therefore, it is easy to measure the velocity of the surface-current, it is difficult, because of this retardation beneath, to determine the mean velocity or actual flow of the river. This has never been satisfactorily done before. Many experiments, with a view to the accomplishment of this end, have indeed been made by eminent men, but they have failed to establish the relationship between the depth of the stream and the velocity of the flow. M. Révy has established that the velocity of a river is directly proportionate to its depth, diminishing or increasing therewith."

It is indeed true that many eminent men have occupied themselves with this problem; but whether they have failed to establish the relation between the velocity and depth is another question, though they certainly failed to find the relation so extremely simple as that determined by M. Révy. In the Government publication referred to, there is an outline of the history of hydraulics applied to rivers, beginning with the contributions to the subject by Castelli, a pupil of Galileo, in 1628, and extending up to the date of the Report. And, by-the-way, Dr. Thomas Young, a portrait and biographical sketch of whom are in the same July number of The Popular Science Monthly, was a contributor to this subject. The numerous formulæ of different investigators are given in the Report, all reduced to a uniform system of notation, but are rather too complicated to be merely copied in a letter, without the accompanying remarks and discussions to render them intelligible.

Again: "It was determined by actual experiment that the greatest velocity of current is at the surface, and the least at the bottom; and that the increase of velocity 'is in the simple ratio of the distance from the bottom.'"

Taking this ratio as true, draw a vertical right line, to any convenient scale of equal parts, to represent the depth of the river at any given place. Then the velocities at different depths would be represented graphically by an inclined right line, the lower extremity coinciding with that of the vertical and the upper at a distance from the upper extremity of the vertical equal to the surface-velocity. Humphreys and Abbot did not find the relation so simple; they demonstrate that "the velocities at different depths below the surface, in a vertical plane, vary as the abscissæ of a parabola, whose axis is parallel to the water-surface," and that "the position of the axis in calm weather is about $\frac{3}{10}$ of the depth below the surface, whatever be the mean velocity of the river." In order to deduce the relation between the velocity and depth, the river-depth was divided into ten equal parts, and the velocity of each was determined by 222 observations; the mean velocity, which was 0.297 D (depth) below the surface, was 3.26 feet; the mean depth 82 feet.

Very many other points of interest are brought out in the Report; such as proving that the curve of surface-velocities is also a parabola, deducing the values of the parameters of these curves, showing how the curves are affected by winds, irregularities of the bottom, etc., etc. The conclusions were deduced from an immense number of observations taken at different times of the year, different stages of high and low river, and at numerous points, by a number of careful and trained observers. In the mathematical discussion of results, the most refined methods were employed.

The current-metre used by M. Révy, although it is stated that he improved it greatly, is open to grave objections, double floats being preferable in point of accuracy in determining the laws regulating the flow of water in river-channels. I have never used any of the patent current-metres, though I have seen and examined them; but I have used the double-floats often enough to be convinced of their utility. I have, however, used an instrument very similar in principle to the current-metre, one of the numerous patent deep-sea leads. This instrument registered depths in fathoms and quarters on an index-wheel turned by the rotation of a propeller, the latter being so arranged as to turn the index-wheel on going down, but, on being drawn up through the water, was thrown out of gear, so as not to unwind the register.

This lead I tested by over one hundred careful soundings, taken at depths ranging from six to fifty fathoms, simultaneous soundings being taken with the patent lead and an ordinary lead-line. The soundings given by the patent lead were so utterly unreliable that I discarded it, and used the ordinary lead-line for the entire work of some pretty extensive hydrographic surveys. To show that this is not merely my own individual opinion about this style of instrument, I will quote, from page 621, Report of the Chief of Engineers for 1870, the criticism of General Abbot upon the same class of instruments:

"In my opinion, founded on a somewhat close study of the subject, instruments of this class are pretty toys, which have contributed more to retard the progress of discovery in the science of river hydraulics than any other one cause. This is due principally to the fact that they register their results in a kind of cipher, to which we can by no means be sure that we possess the key. To translate a given number of revolutions of a submerged wheel into velocity per second, and by this means to detect laws whose existence is denoted only by differences of a few tenths of feet in this velocity, is so delicate an operation that errors in the coefficient have usually masked the laws."

The subject of river hydraulics is quite an intricate one, and not likely to be investigated by people generally. Therefore, an article on this subject in a magazine is apt to be read and its statements accepted with less of questioning than one upon almost any other scientific topic.

I have been a constant reader of The

Popular Science Monthly from its commencement; I know that it has been the aim to make the science of the Monthly not only popular, but accurate, and that must be my apology for writing this letter.

Very respectfully yours,

Charles E. L. B. Davis,

First-Lieutenant U. S. Engineers.

EDITOR'S TABLE.

PROFESSOR NEWCOMB ON AMERICAN SCIENCE.

A NEW standard has grown up in modern times by which the advance of nations may be measured. Hitherto, military power, extent of territory, historic prestige, and commercial resources, have been taken as the chief tests of national greatness. These were old barbaric standards. But, with the progress of civilization, which means the rule of reason in human affairs or the control of society by pacific agencies, new ideals of what constitutes national grandeur are beginning to arise. The relation of nationalities to science may be looked upon as a true test of their rank. Science is an agency of human amelioration universally acknowledged, which is already powerful in shaping the course of the world's affairs; and it is certain to be more and more appealed to in future in determining the order of nationalities in the hierarchy of civilization. What is the relation of a people to science—the highest form of knowledge? How do they estimate it? What encouragement do they give to its original investigation and popular diffusion? are questions not to be neglected in our estimates of national character. How does this country rank with other countries in its appreciation of science? is a home question, which it is desirable to have clearly and decisively answered.

In an able article, entitled "Exact Science in America," published in the last number of the *North American Review*, Prof. Simon Newcomb, Superintendent of the Naval Observatory in Washington, has taken up the subject of the state of science in the United States, and brought us into comparison in this respect with foreign nations. His results are not flattering to our national vanity, and the inferior rank which we take leads him to inquire into the causes of our backwardness. We cannot do our readers a better service than to state some of Prof. Newcomb's main positions, and look a little into the question he raises as to the cause of the present state of things, and what is best to be done. So important is the subject, and so excellent its presentation, that we shall make copious extracts from the article; but we must remind the reader that these extracts are but fragments, and can give no just idea of the unity and fullness of the original statement.

Prof. Newcomb confines himself to a consideration of the state of pure or exact science, "to which we are impelled by the purely intellectual wants of our nature," and omits the applications of science to the arts of life, to which we are impelled by practical motives, and in which "we should find our country in the front ranks of progress." Beginning with mathematics, he says: "When we seek for published mathematical investigation in this country, we find hardly any thing but an utter blank. Of mathematical journals designed for original investigations, such as we find in nearly every country in Europe, we have none, and never have had any. There have been a number of short-lived attempts to establish mathematical periodicals suited to the state of science here, some of them worthy of all praise; but the necessity of adapting their contents to the capacity of their readers prevented them from containing any thing of importance in the way of original investigation." Again: "The only place in which we can search for any thing in the shape of original contributions to mathematics is in the transactions of our learned societies; and here we find, since the Declaration of Independence, a score or two of papers professedly of this character, but it is not likely that more than one or two of them contain any thing worthy of quotation or remark. The whole of them together would not amount to so much as the mathematical journals of Europe publish in a month."

When we pass to the physical sciences, the prospect is said to be a little more encouraging. We have active workers of the highest character in experimental physics, but they are very few, and their productions small. "Here, as in every other science, we find our deficiency to increase just in proportion as the science becomes exact. Many branches of physics have attained, and nearly all the remaining branches are rapidly attaining, the mathematical stage of development. As they enter this stage, we find our American cultivators all dropping off." In exact astronomy, we have the eminent names of Bowditch and Peirce; observatories quite comparable with those of Europe, in charge of first-class men, "yet we do not find our astronomers engaging in investigations of the utmost delicacy; and the first determination of the parallax of a fixed star by an American astronomer has yet to come."

Taking scientific journals and transactions as the measure of work, we have but a solitary periodical of the first rank —*Silliman's Journal.* "Our two most active societies have been the Philosophical Society of Philadelphia, and the American Academy of Arts and Sciences, each of which has brought out about a dozen volumes of transactions since the beginning of the century. Excluding societies whose publications are purely biological, we are not aware that half a dozen other volumes of transactions have appeared within the interval alluded to. Add the eighteen volumes published by the Smithsonian Institution, itself founded by a foreigner, and we shall have a total of between forty-five and fifty volumes in three-fourths of a century. This total, combined product of the Smithsonion Institution and all the scientific societies of the country is about equal to what either the Royal Society or the French Academy of Sciences publishes in one-third the time. . . .

"The great mass of scientific papers in Europe do not, however, appear in transactions, but in scientific journals. Here we stand at a much more striking disadvantage. Against a hundred and fifty or two hundred pages annually on astronomy and physics in *Silliman's Journal*, Germany can show us two journals of pure mathematics, publishing together three or four large volumes of matter every year — two or more of mathematics and physics, one of astronomy, and one of physics and chemistry. Altogether, these journals issue ten or eleven volumes annually, half of them quarto, and half octavo."

Making allowance for a semi-popular element in English original contributions, "it is probable that, instead of finding in England, as we do in Germany, thirty or forty times as much publication of original research in exact science as in America, we should find only five or ten times as much. A comparison with France would probably be more to our disadvantage than that with England, as the *Comptes Rendus* of the French Academy alone contain ten times more matter pertaining to exact science than *Silliman's Journal* does."

In view of these results, Prof. Newcomb remarks: "Making every possible allowance, and viewing the facts from every stand-point, we shall be able to make only the most beggarly and humiliating showing. What is yet worse, we cannot claim to be improving our relative position, but are rather falling back, scientific activity increasing more rapidly in Europe than here."

The question now arises as to the cause of this state of things. "Why, with our numerous educational institutions and our great crowd of professors, should our contributions to the exact sciences be so nearly zero?" And to this question he answers: "The real proximate cause is found in the lack of any sufficient incentive to the activity which characterizes the scientific men of other nations, and of any sufficient inducement to make young men of the highest talents engage in scientific pursuits. The reason that so much more scientific investigation is done in Germany than in this country is, simply, that the inducements to do it are there so much more powerful."

Prof. Newcomb points out that, "in Germany, the seats of scientific activity are the universities; in France and England, the learned societies;" and that, while in Germany it is the professors who make the universities, in this country it is the universities that make the professors. "Students flock to Berlin, not because the university is an old, celebrated, and good one, but to hear Helmholtz and Virchow. If all the men like these should leave the university, the students would follow them. But, in this country, students are not attracted to Harvard and Yale by the names of individual professors, but by the reputation and organization of the colleges." Professors may, perhaps, be held in as high esteem here as in Germany, but for different reasons. The question in Germany is not, How much does he know? but, What has he added to knowledge? "What has he discovered that is new? what doubts has he cleared up? what fallacies has he exposed? what increase of precision has he given to the subject he has studied?" On the contrary, in our own so-called universities, "nothing more is expected of a professor than acquaintance with a certain defined curriculum and ability to carry the student through it. He has nothing to do but to satisfy the appointing power that he understands what is found in a certain text-book, and that he can teach what he knows to others." He is not for a moment expected to be an original investigator; while, for the kind of work not required here at all, the German is held in the highest estimation, and may secure large pecuniary rewards, and a position in the affections of a large body of educated men.

In England and France, on the contrary, it is not the universities but scientific societies which furnish the incentives to research. "It is a fact which we have to face, and which it would be folly to disguise, that our scientific societies do not compare with those of England in wealth and power. . . . The great weakness of most of our scientific organizations does not, however, consist in the want of financial means, but in something much more difficult to determine and define. We can only say that, with a few exceptions, they exhibit a total lack of cohesive power, vitality, and that undefinable something which may be called weight and importance. However eminent may be the men who compose them, most of them are, as organizations, insignificant, and exhibit the same liability to die from slight causes that weak and sickly individuals do. A history of all the attempts to organize learned societies in this country would afford an instructive study in human nature, and might show that they died by causes as uniform as those which cause the decay and death of individuals. . . .

"The important fact which we wish to impress on the mind of the reader is, that, when an Englishman makes any scientific investigation or discovery of merit and importance, he is considered a valuable member of society, and society takes pains publicly to indicate its appreciation of his value. When we say that in this country one may devote his life to science, and may gratuitously give to scientific investigation an amount of labor and talent which would secure him both wealth and distinction in any other profession, without receiving therefor a solitary public mark or expression of appreciation from any source whatever, or the slightest additional consideration from the public, hardly any thing more is necessary to show that there is here comparatively little incentive to such work."

The backwardness of science in this country is thus attributed to the lack of those incentives to its cultivation which come from public appreciation. There is talent enough, there are facilities enough, there is interest enough in research, but there is no sufficient external spur to scientific exertion. Men will not toil where their labors are unappreciated, and the general esteem of science is too low to arouse and sustain the necessary ambition in its original cultivators. Assuming this to be a correct view of the case, the question arises, What is to be done? Are we to try to repeat the experience of Europe? In European countries there has been the slow and gradual differentiation of a scientific class which has its wealthy, powerful, and venerated organizations that form a kind of scientific world, the approbation and rewards of which are sufficient to stimulate men to give their lives to research. No such class has been developed here. Our investigators are too few and widely scattered, and their associations are too weak to give inspiration and support to original work. It is a case of immaturity, and Europe has the start of us by centuries. We have tried to imitate the foreign academies and associations, but the effort is futile, for the lack is of scientific feeling—motive power to work—and that cannot be created by acts of corporation. Obviously, therefore, from the nature of our circumstances, scientific development in this country must take a different course, and connect itself with general education and public opinion. As long as we rely upon imported methods of nurture, science must languish in this country, and fall further and further behind; but when the policy of the advancement of science is made to conform to the character of our institutions, when science takes the place to which it is entitled in our system of popular education, then may we expect such an increasing appreciation of it as will give much stronger incitement to the work of original investigation. But in this matter of the popular diffusion of science it seems there has been even less interest here than abroad. Prof. Newcomb says:

"Our instrumentalities for communicating to the educated public a knowledge of the doings of the scientific world have, until very lately, been nearly as defective as our means of scientific publication, and, notwithstanding certain recent improvements, are still far behind those of other nations. In England, France, and Germany, weekly, monthly, and quarterly journals of popular science are too numerous to be recounted; while, previous to the establishment of The Popular Science Monthly by the Appletons, we had not in this country a single journal designed to diffuse the knowledge either of general or exact science. The *American Naturalist*, as its name implies, is devoted entirely to biology. One of our principal scientific wants has been a publication which should serve as a medium of communication between scientific men and the educated public, as well as between the various classes of scientific workers."

And again: "Within the past three or four years there has been a large increase in the amount of popular scientific publication in this country, which is seen in the establishment of a scientific magazine, and in the appearance of 'scientific columns' and 'scientific departments' in many of our newspapers and magazines. But the great object of educating the intelligent public in scientific matters is very imperfectly fulfilled by these publications. A considerable portion of the matter they present to us consists of fugitive items, hardly more interesting or important than the column of daily clippings, of one short sentence each, which has become a feature of our newspapers. The most notable exceptions have been the 'Science Department' of the *Atlantic Monthly* while it lasted; the 'Editor's Table' of The Popular Science Monthly, and, of late, the 'Science Record' of *Harper's Magazine*. Here we have found original discussions of scientific questions, and reviews of the progress of science by competent writers. For the rest of The Popular Science Monthly so much cannot be said. When first started, it was mostly made up of extracts from English publications, and of essays, which could hardly have found a place in any other publication. Of late, it has gradually improved by including more original matter, and that of a better class. But it has never attempted to supply the great want to which we have referred, namely, that of making known the progress of science in this country; and the reader who wishes to learn what our scientific men are doing here, will find far more copious accounts of it in *Nature*, an English periodical, than he will in the American magazines referred to."

And for this defective state of scientific journalism, by which "the great object of educating the intelligent public in scientific matters is very imperfectly fulfilled," we beg to ask, Who is mainly responsible? What have our eminent scientific men themselves done toward this important work of popular scientific education? Is it too much to say that, as a class, they have neglected it, and that many of them have repudiated it? They have left it to half-instructed men—to men without scientific position—and, when it was poorly done, have cast reproach upon their work. Some of our distinguished scientific men have indeed indulged more or less in popular lecturing, but often with vehement protests against the degradation, and obtrusive statements that they did it for the sake of the money alone. What have they attempted, in any concerted or systematic way, through associations or publications, "to educate the intelligent public into an appreciation of the importance of scientific investigation?"

Prof. Newcomb bears witness upon this point when he says that, "previous to the establishment of The Popular Science Monthly by the Appletons, we had not in this country a single journal designed to diffuse the knowledge either of general or exact science;" that is, scientific men had contributed absolutely nothing in the way of a periodical devoted to the promotion of their own most vital interests. We showed, in the October Monthly, how the American Association for the Advancement of Science in its organization carefully avoided committing itself to any agencies of popular influence, and deliberately placed itself behind the British Association in this respect. If the education of the public to a better appreciation of science is the one thing needful to relieve this country from the odium of its position upon this subject, and the one thing necessary for the liberal encouragement of a scientific class, why has our leading body of scientists so studiously refrained from taking any action toward so desirable an end? The subject of general scientific education is now widely confessed to be of great public moment. The community is not only ripe for action upon it, but in the chaotic state of school instruction it is asking for light and guidance as to the methods that shall be adopted. Help should have come from men of authority, and an expression of the American Association would have had great weight and a salutary influence with the people. Yet a committee was appointed at its Portland meeting to report upon the subject of better methods of general scientific instruction, and at the recent Hartford meeting it was discharged without having done any thing, the chairman stating that he had never even heard of his appointment! This indifference, we think, is very much to be regretted.

Prof. Newcomb says that The Popular Science Monthly has never attempted to supply the great want of making known the progress of science in this country, and is even behind the English periodical *Nature* in this respect. It certainly was not the chief object of the establishment of this magazine to report the doings of American investigators, and this for several reasons. In the first place, the field was already occupied by a journal of high character, which, with the proceedings of scientific societies, gave this information to the class most wanting it—the students of science. Moreover, the public press has latterly entered upon the work, and is constantly seeking for scientific novelties, as matters of ordinary news. Besides, as Prof. Newcomb shows, American contributions to the progress of science are but an insignificant portion of the total work that is doing in the scientific world, of which no single periodical could give even a synopsis. Nor is it to be forgotten that an immense amount of that which is currently published as "new results" has but a momentary importance! But a small portion of such work stands the test of time. Of the score or two of original contributions to mathematics, published in the transactions of our learned societies since the Declaration of Independence, Prof. Newcomb assures us that "it is not likely that more than one or two of them contain any thing worthy of quotation or remark." With this enormous shrinkage of scientific values, we think it is quite as well that the new results should be tested, discussed, and the chaff blown away by scientific criticism, before the final product is pressed upon the general public.

But the strongest reason why the Monthly has not assumed the duty of reporting American scientific work is, that is was started for distinctly another object—namely, to interest the non-scientific public, and to create a taste for scientific literature, and an appreciation of scientific knowledge in the reading community. The general ignorance of science is simply deplorable! The literary culture to which general education is committed does not lead to science, but, by its exclusive claims and overshadowing influence, hinders and prevents its study, so that, among so-called intelligent people, the ignorance of scientific subjects is so gross as to give much excuse to scientific men for their contempt of the hopeless work of its popularization. Between the state of mind of learned scientific explorers and that of the mass of magazine-readers throughout the country the gulf is already wider than the Pacific Ocean, and is constantly widening. As regards science, there is very little that is common between them. But a journal which aims to influence a non-scientific public must be somewhat suited to its state of mind, or it will not be read. Were we to fill the Monthly with the results of laboratory processes and observatory work, or with that which most concerns investigators, it might rise in appreciation with them, but it would not be wanted by the people, as all experience with such publications has shown. The public needs rudimentary explanations much more than the "last results" of science. The theory of this periodical is, that those who write for it shall turn their backs upon the scientific world, and address themselves to a class so uninstructed in scientific matters that every thing requires to be explained. That we have realized this ideal is not claimed; but, granting that "the great object of educating the intelligent public in scientific matters is very imperfectly fulfilled" by this publication, we have Prof. Newcomb's authority that it was not fulfilled at all by any previous periodical in this country. Our enterprise had no precedent, and, such were its obvious difficulties, that, at starting, it was generally supposed it would be a failure. We are quite aware of its shortcomings, and, thanking Prof. Newcomb for the recognition of its improvement, we hope that it will continue to grow better. But, as our pages attest, it has not been unmindful of the advances of inquiry, though it has given prominence to those extensions and widenings of scientific thought in which we believe the public has a growing interest; for the advance of science does not merely consist in new physical and chemical experiments, new mathematical solutions, or astronomical discoveries; it consists quite as much in scientific modes of thinking applied to subjects not hitherto dealt with by such methods. The great difficulty is, that the instruments, processes, problems, and general subject-matter, of advanced investigation are so completely removed from general experience; and the public interest, we think, can never be seriously enlisted in scientific inquiries until they take account of phenomena, facts, and questions, that fall within the range of familiar observation and common thought. That the public is to-day far more interested in the relations of science to religion than they are in science itself, is because one term of the relation is so thoroughly familiar to the general mind.

LITERARY NOTICES.

The Physiology of Man: Designed to represent the Existing State of Physiological Science, as applied to the Functions of the Human Body. By Austin Flint, Jr., M. D. In Five Volumes. Volume V. Special Senses; Generation. New York: D. Appleton & Co. 517 pages. Price, $4.50.

The fifth and concluding volume of Dr. Flint's comprehensive work on physiology is now published, and we congratulate the author upon the completion of his task and the success of its execution. We gave a brief account of the general object of the work, in noticing a previous volume, and have only now to say that the concluding book of the series not only sustains, but surpasses, the high character won by its predecessors, while the whole work—the product of eleven years' labor—is an honor to its author and a credit to the science of the country.

The literary merit of these volumes, we think, deserves especial recognition; that is, their style is admirably adapted to its purpose of conveying clear impressions to the reader with a minimum of effort on his part. To the general reader, there is necessarily a certain amount of hindrance from the use of the unfamiliar terms of the science; but, in no first-class work upon the subject, that we remember, is there so little embarrassment on this score as in that of Dr. Flint. In his style he has attained the excellence of a lucid simplicity, one of the perfections of art which is the more remarkable, as, being a laborious experimental physiologist, busy firstly and mainly with his science, he cannot have had much time to spare for literary discipline. It is a general fault with our scientists, that they too much neglect literary cultivation, and break down in the arts of statement; Dr. Flint is not open to this criticism. Hence, while his work will have an increasing value for physiological students, it has also peculiar claims on non-professional readers who may care to consult an elaborate treatise upon the subject.

In regard to the original character of the work, and its claims as a whole fairly to represent the present state of the science, the author says, in his preface:

"In the preparation of this work, the author has formed his opinions, to a great extent, from the results of direct observation and experiment, as the true basis of what is positively known in physiology; aud, while the earlier volumes might be modified by the addition of new facts, they contain comparatively little that has been disproved by recent investigations. Experimental observations have been studied and criticised from a practical point of view; and in this the author's training, as an experimentalist and a public teacher for more than fifteen years, has given him a certain degree of confidence. It is the practical physiologist who is best qualified to judge of the correctness of physiological experiments, and of the accuracy of methods of investigation; and the author has learned, from his own attempts at original observation, to estimate the difficulties of direct research, and to appreciate the inaccuracies into which careless, inexperienced, or over-enthusiastic workers are liable to fall."

Evolution and Progress: An Exposition and Defense. The Foundation of Evolution philosophically expounded, and its Arguments succinctly stated. By Rev. William I. Gill, A. M. New York: Authors' Publishing Company, 30 Bond Street. 295 pages. Price, $1.50.

This little volume has some striking characteristics which take us somewhat by surprise. It is a prize essay of the Authors' Publishiug Company, and a thoroughgoing defense of the doctrine of Evolution by a working orthodox clergyman. Its dedication is significant of the progress of catholic views, such as we hardly expected to see in this generation: "To Herbert Spencer, Esquire, and the great brotherhood of evangelical divines, the author dedicates 'Evolution and Progress,' in token that the full complement of truth must ensphere all the antipodes of thought." The volume is mainly a discussion of the principle of Evolution in its highest philosophical aspects, and the argument is conducted in the most interesting manner, by taking up the objections of its leading opponents, as Dawson, Winchell, and Bowne, and its *quasi* opponents, as Dr. Carpenter and Prof. Le Conte. The author writes from his point of view as a clergyman, not in the narrow professional sense, but as an uncompromising devotee of truth in its unity and completeuess. He has his own views, and, while accepting Evolution in its broadest sense, and shrinking from none of its consequences, he yet holds it to be but a part of a larger order of philosophy yet to be worked out. In his preface, he says:

"For himself, the writer cares very little for Evolution as an ultimate system of philosophy. We think its method, so far as it goes, is philosophical, its arguments sound and logical, and its conclusions invulnerable against any thing that has yet been brought to bear against them. But we want, however, to go farther and get something broader and more profound—something that leaves intact what Evolution has disclosed, but finds it a place in a larger scheme, and ennobles it by the new and higher relations into which it is thus brought. But incomprehensive and uncomprehending dogmatism, whether for or against Evolution (for it belongs to both sides), stands in the way, and demands that progress shall be in a circle. But it is orthodox dogmatism which, on this subject, is most obstructive of progress; and it therefore requires to be startled, if not stunned, into the perception of its philosophically defenseless and helpless condition, so as to make it see a new light, and accept the offer of more effective weapons. Kant confessed that the skepticism of Hume broke the dogmatic slumbers which he was indulging on the iron bed of the Leibnitzo-Wolfian philosophy, and thus quickened the world afresh into thought. Evolution is surely destined to perform the same office more healthfully for the complacent slumberers of this age, whether physical, metaphysical, or theological slumberers. To make a small contribution toward this result, is the object of this monograph.

"There are many who are crying, 'Peace, peace!' where there is no peace; and they are healing their theological hurt slightly—daubing with untempered mortar. They bless their superannuated philosophy with the wild belief that Evolution is becoming exhausted—going off into a decline, and that it will soon die of inanition. On the contrary, it is like the mountain-stream, making fresh acquisitions, and increasing in strength and volume as it rolls; and must continue so to do till it is lost in the ocean. Evolution is now made the foundation of religious rationalism in England and America; and the best foundation it has ever had—one which can easily be exhibited to the common people; and the 'liberal' pulpit is becoming fervent and attractive in its efforts to show how the Gospel can be and should be accommodated to Spencerianism, and how this system furnishes the best philosophy of religion. Practically, therefore, it is not to be ignored and pooh-poohed, or treated with indifference by the evangelicals, as some of them affect to do. Never was thought so active as it is to-day, and never was there so large a number of great and cultured and eminently virtuous and dispassionate minds who doubt or disbelieve the existence of a personal Deity. Whither are these facts pointing?"

The author thus explains the origin of his work:

"This book was at first designed only as a brief essay, as a private discussion with a friend, and it originated as follows: Conversing with Prof. B., of —— Theological Seminary, I asserted that the orthodox do not understand their opponents, that in the present state of philosophy Evolution can be rigidly maintained and triumphantly vindicated against all the assaults of Theism, and that the latter will have to adopt an entirely new method of defense and attack; and, as the professor disputed this, I promised to prove it in a short article, which now turns out to be a book. The object, therefore, of this volume is complex—first, to show to the orthodox that they stand on slippery places, that their philosophy and logic can afford them no legitimate aid and comfort; second, to show to the quasi-evolutionists that there is no medium between atheism, or non-theism, and the rejection of their own principles of science and philosophy; third, to show to the thorough naturalistic evolutionists that there is at least one man among the orthodox who thoroughly understands them—knows them better even than they know themselves—and who grants them all their principles, better expounded, and admits their legitimate consequences; and, fourth, that therefore the author must accept not only these principles, but also these consequences, unless he can furnish a new philosophy which shall use these acknowledged principles in combination with others, and thus attain other, or, rather, higher results. This the author believes to be possible, and that he is called to attempt it."

In conclusion, Mr. Gill says:

"We by no means consider the doctrine of Evolution, even in the most advanced philosophical state in which it has been presented, to be an all-comprehending philosophical ultimatum. We hold that it is just in its conclusions from its premises, and that its premises are indisputable. But there are broader and profounder truths yet undeveloped, which are partially and falsely discerned, and ignored or rejected; truths which, when fully expounded in their legitimate connections, will show that Evolution, instead of being the ultimate philosophy of the universe as it now appears, is infinitely subordinate; and these truths will introduce and demonstrate an infinitely sublimer theory, which will comprise Evolution as a vast temple comprises each of its most miniature figures, or as the material universe comprises each of its countless atoms.

"The theory of Evolution contains a body of facts, of deductions, of inductions, and of generalizations, so irrefragably true that, though they may be subsequently covered by further discoveries of facts and by deductions and inferences and broader generalizations, they cannot be overthrown; or, in other words, they may be absorbed, but cannot be refuted. We propose to cover and absorb them. . . .

"The absolute unity of the known universe is no longer to be questioned, and as now conceived it precludes a personal Deity and our personal immortality. Now the great problem is: Can we expound this unity so as to prove a personal Deity and our personal immortality? With emphasis I answer—Yes."

Animal Mechanism. A Treatise on Terrestrial and Aërial Locomotion. By E. J. Marey, Professor of the College of France. Profusely illustrated. 283 pages. Price $1.75. D. Appleton & Co. No. XI. International Scientific Series.

The author of the present work, it is well known, stands at the head of those physiologists who have investigated the mechanism of animal dynamics; indeed, we may almost say that he has made the subject his own. By the originality of his conceptions, the ingenuity of his constructions, the skill of his analysis, and the perseverance of his investigations, he has surpassed all others in the power of unraveling the complex and intricate movements of animated beings. We last month gave an exemplification of his method in the case of human locomotion, and in the present number of the Monthly we continue the subject by briefly showing his mode of studying the various paces of the horse. The volume deals systematically and thoroughly with this whole subject, and is full of novelty and curious interest. Prof. Marey's elucidation of the mechanism of flight in birds and insects is one of the most exquisite pieces of experimental investigation that modern science affords. The fertility of his devices, by which the varied results are brought out in all their exactness to the eye, by the graphic method of illustration, is a source of constant surprise to the reader. He makes pictures of all his facts and laws. Of course the value of such investigations stands upon their own scientific merits, but they have a peculiar attractiveness as connected with the phenomena of life in which we are all concerned. Yet there can be no greater mistake than to suppose that such researches are destitute of practical utility. Upon this point Prof. Marey has the following excellent remarks in his introduction:

"The comparison of animals with machines is not only legitimate, it is also extremely useful from different points of view. It furnishes a valuable means of making the mechanical phenomena which occur in living beings understood, by placing them beside the similar but less generally known phenomena which are evident in the action of ordinary machines. In the course of this book, we shall frequently borrow from pure mechanics the synthetical demonstrations of the phenomena of animal life. The mechanician, in his turn, may derive useful notions from the study of Nature, which will often show him how the most complicated problems may be solved with admirable simplicity.

"It is easy to demonstrate the importance of such a subject as locomotion, which, under its different forms, terrestrial, aquatic, and aërial, has constantly excited interest. Whether man has endeavored to utilize to the utmost his own motive power, and that of the animals; whether he has sought to extend his domain, to open a way for himself in the seas, or rise into the air, it is always from Nature that he has drawn his inspirations. We may hope that a deeper knowledge of the different modes of animal locomotion will be a point of departure for fresh investigations, whence further progress will result.

"Every scientific research has a powerful attraction in itself; the hope of reaching truth suffices to sustain those who pursue it, through all their efforts; the contemplation of the laws of Nature has been a great and noble source of enjoyment to those who have discovered them. But to humanity, science is only the means, progress is the aim. If we can show that a study may lead to some useful application, we may induce many to pursue it, who would otherwise merely follow it from afar, with the interest of curiosity only. Without pretending to recapitulate here all that has been gained by the study of Nature, we shall endeavor to set forth what may be gained by studying it still further, and with more care.

"If we knew under what conditions the maximum of speed, force, or labor, which the living being can furnish, may be obtained, it would put an end to much discussion, and a great deal of conjecture, which is to be regretted. A generation of men would not be condemned to certain military exercises which will be hereafter rejected as useless and ridiculous. One country would not crush its soldiers under an enormous load, while another considers that the best plan is to give them nothing to carry. We should know exactly at what pace an animal does the best service, whether he be required for speed, or for drawing loads; and we should know what are the conditions of draught best adapted to the utilization of the strength of animals.

"It is in this sense that progress is being made; but, if we complain with reason of its slow advance, we must only blame our imperfect notion of the mechanism of locomotion. Let this study be perfected, and then useful applications of it will soon ensue.

"Man has been manifestly inspired by Nature in the construction of the machinery of navigation. If the hull of the ship is, as it has been justly described, formed on the model of the aquatic fowl, if the sail has been copied from the wing of the swan inflated by the wind, and the oar from its webbed foot as it strikes the water, these are but a small part of Nature's loans to art. More than two hundred years ago, Borelly, studying the stability and displacement of fish, traced the plan of a diving-ship constructed upon the same principle as the formidable *monitors* which made their appearance in the recent American war.

"Aërial locomotion has always excited the strongest curiosity among mankind. How frequently has the question been raised, whether man must always continue to envy the bird and the insect their wings; whether he, too, may not one day travel through the air, as he now sails across the ocean! Authorities in science have declared at different periods, as the result of lengthy calculations, that this is a chimerical dream; but how many inventions have we seen realized which have also been pronounced impossible! The truth is, that all intervention by mathematics is premature, so long as the study of Nature and experiment have not furnished the precise data which alone can serve as a sound starting-point for calculations of this kind."

The Maintenance of Health. By J. Milner Fothergill, M. D. London: Smith, Elder & Co. New York: G. P. Putnam's Sons. 399 pp. 8vo. Price, $5.00.

This is a useful work on hygiene, and, as all intelligent hygienic action must be based upon some knowledge of the human subject, it opens with a description, in outline, of the composition of the body, of its various organs, the functions they perform, and the relations of food, exercise, and sleep. Then follows a consideration, in the natural order, of youth, maturity, and old age, with the dangers incident to each, and the precautions necessary.

In treating of the first stage, allusion is made to a danger little known and less heeded by people in general: this is, the effect upon children of violent outbursts of anger in parents and nurses. The young wife, by yielding to anger under the trials of her newly-assumed position, may doom her unborn babe to an imbecile existence. "The majority of imbeciles are first-born children, and their pitiful condition is the consequence of the mental perturbations during the term of pregnancy." Again: "In sucklings, too, mental disturbance in the mother or wet-nurse will commonly produce indigestion and diarrhœa in the baby." Nor does the danger end with infancy. Nearly every one has observed the deplorable influence which capricious paternal anger exercises upon children, some being made gloomy and morose thereby, others stubborn and revengeful. In connection with children advanced beyond the period of infancy, the author deplores the aversion, which they at the present day display, to eating fat, and recommends that parents should persistently endeavor to counteract it. He says: "Fat is most necessary to the proper growth of tissues, and, such being the case, is still more necessary to children." Without it, children grow up lean and spare.

The consideration of the causes of diseases in maturity is worthy of special attention. One of the most subtile of these causes, because little thought of, is the decay of the teeth. This is said to be on the increase, and is mainly attributed to excessive consumption of sugar, and the use of dentifrices. "Many dentifrices contain an acid which, by constantly eating away a thin surface of the enamel, keeps the teeth brilliantly white, but in time leads to their utter destruction."

Certain silly young ladies, who resort to the drinking of vinegar or the eating of raw rice, to avoid growing fat and florid, will be edified to learn that the amount of vinegar which will make them thin will destroy their digestive powers, and that a similar quantity of rice will produce habitual constipation, and prevent the assimilation of food.

In advanced life, many persons suffer much from inability to sleep. Moderate exercise during the day, and, at night, beds warmed before retiring, are recommended as the best remedies. In obstinate cases, a little alcoholic stimulant, mixed with warm water, may be taken to advantage just after entering bed. An important chapter is devoted to food and clothes, and another to stimulants and tobacco. The recent classification of alcohol as a food is adopted, and its use in small quantities considered harmless; in certain cases beneficial. Tobacco is also considered harmless in moderate quantities.

The chapter on mental strain, overwork, and tension, deserves a careful perusal. Men unfamiliar with the symptoms of an approaching breakdown of their mental powers, frequently work on blindly until comes the fall from which no power can lift them. Sleeplessness is one of the most significant warnings, and should never pass unheeded. In this connection, the author's remarks on the use of chloral hydrate, as an agent for promoting sleep, serve as a timely warning against that deadly remedy. Its action on the nerve-centres is destructive, and it produces a permanent condition of brain-bloodlessness fatal to mental vigor. Hygiene is the subject of an able discussion. The book will, unquestionably, prove of great value to those who read it carefully. It is not, however, intended as a family prescription-book, but as a safeguard against disease. In every case of actual sickness, it advises that the family physician be sent for.

Cave-Hunting: Researches on the Evidence of Caves respecting the Early Inhabitants of Europe. By W. Boyd Dawkins, M. A., F. R. S., etc. London: Macmillan & Co. 455 pp. 8vo. Price, $7.00.

The prefatorial remarks of the author announce that this book is a faint outline of a new and vast field of research, intended to give prominence to the more important points, rather than a finished and detailed history of cave-exploration.

Caves have in all ages, and in all countries, been regarded with feelings of superstitious veneration; here, as the dwelling-places of the sibyls and nymphs, there, as the shrines of Pan, Bacchus, Pluto, the seat of the oracles of Delphi and Mount Cythæron, and in the far East they were connected with the mysterious worship of Mithras. These feelings long secured them from intrusion and exploration. At length, in the sixteenth and seventeenth centuries, they were thrown open for examination by the desire which then arose in Germany to possess the "*ebur fossile*," or "unicorn's horn," a supposed infallible specific for the cure of many diseases. The "unicorn's horn" was to be found in the caves, and the search for it revealed the remains of lions, hyenas, elephants, and many other tropical or strange animals. At first these remains were supposed to have been washed thither from the tropics by the Deluge. Then the truth began to dawn that the animals lived in the surrounding country, and that the bones of such as were not cave-haunting were dragged into the caves by such as were. This truth was first enunciated by Rosenmüller in 1804. Between 1825 and 1841, an Englishman, the Rev. J. McEnery, discovered in Kent's Hole, near Torquay, the first "flint implements" ever observed, in a cave along with the bones of extinct animals, and he suggested that they proved the existence of man at the same time with those animals. But he died in 1841, leaving his suggestion scornfully repudiated by the scientific world; although, in 1840, Mr. Godwin Austin, by independent researches, verified its truth. It was not until after 1859 that the significance of this discovery came to be generally perceived and admitted. It, of course, immediately revolutionized the prevailing notions of the antiquity of man, while the previously-accepted theory of Rosenmüller unmistakably indicated the occurrence of remarkable geographical and climatal changes over the continent of Europe. The work before us traces the rise and progress of cave-exploration; considers the physical history of caves, that is, their formation, whether by sea or volcanic action; enumerates the most remarkable caves, with the objects they have yielded; treats of the character of the early inhabitants of Europe, and of the fauna of the same period, as indicated by the remains discovered; and, finally, of the climatal and geographical changes that have occurred since those deposits were made. The style is clear and vigorous, and the text is interspersed with numerous illustrations. The work will commend itself to all who have a desire to know something of what humanity was in that hazy period which stretches backward of the earliest records.

Lecture Notes on Qualitative Analysis. By Henry B. Hill, A. M. (Assistant Professor of Chemistry in Harvard College). New York: G. P. Putnam's Sons. 54 pp., 12mo. Price, 75 cts.

This little book is designed for the use of the chemical student. Explanatory of its object, the author says, in his preface, that, during lectures, the student being under the necessity of taking notes, is often prevented from seeing what takes place on the lecture-table. The book is intended to give concisely the facts essential to intelligent work in the laboratory, that the student may have more leisure for observation in the lecture-room. The work shows the divisions of the bases and the acids into groups, as well as the means of detecting them; also directions for the examination of specimens, the reactions of various substances under different circumstances, and the method of treating them with water and with acids.

Deutsche Rundschau. Herausgegeben von Julius Rodenberg. Monthly. $10 per annum.

This is the first number of a Review, intended to occupy, in German periodical literature, about the same rank that is held by the *Revue des Deux Mondes* in the periodical literature of France. Like its French prototype, it will contain novelettes and continued stories, historical sketches, political articles, scientific essays, poems, etc., together with book reviews, criticisms of music and the drama, and political notes. The scientific article in the present number is entitled "Botanical Problems," and is written by Prof. Ferd. Cohn, of Breslau. Stechert & Wolff, 4 Bond Street, New York, receive subscriptions for the *Deutsche Rundschau* in the United States.

PUBLICATIONS RECEIVED.

Lecture Notes on Quantitative Analysis (Hill). New York: Putnam's Sons. Pp. 64. Price, 75 cents.

Operation for Cataract (Jeffries). Pp. 15.

Insanity and Disease (Tourtellot). Pp. 15.

Catalogue of Plants (Wheeler's Expedition, 1871–'72–'73).

Ornithological Specimens (Wheeler's Expedition, 1871–'72–'73).

Archives of Dermatology (Quarterly). Putnam's Sons. Pp. 96. Three dollars per annum.

American Journal of Insanity (Quarterly). Utica, N. Y.: State Lunatic Asylum. Five dollars per annum.

MISCELLANY.

Does the Earth rotate at a Uniform Rate?—In the September number of *Silliman's Journal*, we find a remarkable paper by Prof. Newcomb, of the Naval Observatory, Washington, to the conclusions of which we wish to call the attention of our readers.

Prof. Newcomb, who has for some time been engaged on the most difficult problem of celestial mechanics—the "Theory of the Moon's Motion"—published, in 1870, a paper referring to some of the difficulties in this theory. He has treated the lunar theory in quite an original and exhaustive manner, and, in the course of his investigations, arrived at the fact that there were certain outstanding differences between theory and observation which had not yet been accounted for by the gravitation of the known bodies of the solar system. Prof. Newcomb suggested that there were only three possible explanations of the discrepancy: 1. The mathematical analysis was not sufficiently extended; 2. The motion of the moon was affected by some force different from gravitation; 3. The time of the earth's rotation on its axis was not constant.

The second hypothesis Prof. Newcomb showed was not at all probable, since the effects of a force other than gravitation would produce variations of a different kind from the ones actually noticed: the first hypothesis Prof. Newcomb has, since 1870, been engaged in testing, and his researches have convinced him that analysis has taken cognizance of every important inequality in the moon's motion. This makes it necessary to examine rigorously the third hypothesis, viz., that the earth's time of rotation on its axis is not strictly uniform.

This explanation is, at first sight, somewhat startling, since the absolute uniformity of the sidereal day has long been supposed certain. Prof. Newcomb's researches in 1870 led him, however, to the conclusion that the earth had been rotating somewhat slower than the average rate for ten or twenty years previous to 1860; that about 1860 the rotation was accelerated, so that there was a gain of *at least* a second per annum till about 1872.

This hypothesis would, we must remember, account for the inequalities in the moon's motion, but it rested on no independent basis. Since that time, Prof. Newcomb has devised a method of testing this question by totally different means, viz., by an examination of the eclipses of Jupiter's first satellite; and this test has been applied by Mr. Glasenapp, an astronomer of Pulkova. Mr. Glasenapp's researches indicate with great certainty that the earth's rotation is not strictly uniform, and that Prof. Newcomb's hypothesis is sustained. The accurate determination of the amount by which the earth is fast or slow is yet to be reached, but we must accept two important facts as probable: 1. That the earth's rotation time is not strictly constant. 2. That the inequalities in the moon's motion are largely, if not wholly, due to this.

Growth and Reproduction of the Antlers of the Deer.—John Dean Caton, whose observations on the natural history of the American *Cervidæ* are familiar to the readers of Mr. Darwin's writings, contributes to the *American Naturalist* for June an important paper on the "Structure and Casting of the Antlers of Deer." He shows, in the first place, the substantial identity of structure between the antlers and the ordinary bones; in fact, the antlers are *external* bones, of very rapid growth, which mature speedily, die, and are soon thrown off; while all other bones are very slow of growth, and persist through life.

The process of growth is as follows: The old antler having fallen off, the blood-vessels of the periosteum at its butt are ruptured, producing a copious flow of blood. Next, the periosteum grows over the cavity in the top of the *pedicel*, or process of the skull on which the antler stood. On the approach of spring, this covering becomes inflamed, resembling a blood-blister. It rises up rapidly, new systems of blood-vessels forming in it, till its height is twice its diameter; then an osseous deposit is commenced at the circumference of the top of the pedicel. As this deposit rises it thickens very slowly, the upper extremity presenting a thin, serrated edge. Blood-vessels from the periosteum traverse this tissue, supplying it with nourishment. This is the source of supply from without; but there are internal sources also, viz., arteries passing up through the pedicel, and answering to the medullary arteries of long bones.

At the extremities, first, the deposit of earthy salts goes on till this fills up the canals leading from the periosteum into the bony mass, so that the circulation through them is obstructed; and this process goes on till all communication between the internal and the external blood-vessels is severed. The animal is now prompted, by some natural impulse, to rub off this outer covering, while it is gorged with blood. The cavities in the branches and the upper portion of the beam soon become hardened throughout, and the solid wall in the lower part much thickened. Before the central section has become solid, the nutrient vessels are obstructed below, and the deposit of bony particles arrested, while yet the larger portions of the antler are more or less porous. This makes the antler lighter, without seriously diminishing its strength, for its walls are braced within, in every imaginable direction, by thin plates of bone.

In the mean time, the lower extremity, too, becomes more and more compact, and the pedicel, which, during the active growth of the antler, was open and porous, commences a new deposit of laminæ in its cavities. But now, all sources of nutriment having been cut off, the antler dies, and is removed by a singular process. One of the systems of blood-vessels which supply nutriment to the growing antler commences active operations to undermine it. The absorbents of these blood-vessels attack the point of junction between the antler and the pedicel. They do not carry away the surface of the bone evenly, so as to make it smooth, but, as it were, they remove alternate particles, till the union, which before was so firm that no force could break it at the point of juncture, has become so weakened that the antler is detached by some slight violence.

A Remarkable South American Valley.—According to *Iron*, the upper valley of the Rio Madeira, one of the chief tributaries of the Amazons, rivals California and Australia in mineral wealth. This valley, which contains about 400,000 square miles, is marvelously rich in every South American product of value. Its eastern and central parts, the Bolivian provinces of Cordillera, Chiquitos, and Beni, were first settled by the Jesuits, who penetrated northward from their settlements in the valley of the Rio de la Plata, and organized numerous "reductions" of the native tribes, and founded many prosperous towns. These, however, were always either on the banks of navigable streams, or within easy reach of them. In the extreme eastern part of the Madeira Valley is the Brazilian province of Matto Grosso, abounding in valuable agricultural products, and gold and diamond washings. Owing to its inaccessibility, it is very thinly populated, but no doubt, in the future, will be one of the most prosperous states of the Brazilian Empire. At present, it is one of the most unprotected frontiers of that country, being almost at the mercy of the states of the La Plata Valley in case of war.

Ascending the upper central and western rivers of the Madeira Valley, we come to the richest of all the slopes of the Andes, well populated by the Spanish race, mixed with Quichua and Aymara Indians, the Indian element being probably the best on the American Continent. The Bolivian part of the valley contains about 2,500,000 people, the Indian blood slightly predominating. At the date of Bolivian independence, 1825, the population was under 1,000,000. The country in which they live is, without exception, the richest on the globe, in every thing that Nature gives to man. Its mineral wealth cannot be matched within an equal area on the Western Continent. The number of silver-mines opened there during Spanish rule might appear fabulous, were they not registered in the archives of the state: they exceed 10,000! From the banks of the little streams which feed the Beni branch of the Madeira, gold may be washed almost anywhere. In fact, the whole slope of the Andes, in an immense sweep of 1,000 miles, extending from Cuzco to Matto Grosso, is a vast gold-placer.

A Rare Species of Rabbit.—In Prof. Hayden's "Report of the Geological Survey of the Territories" for 1872, Mr. C. H. Merriam describes a very rare species of rabbit (*Lepus Bairdii*) inhabiting the pine-regions about the head-waters of the Wind and Yellowstone Rivers, in Wyoming. Mr. Merriam secured five specimens of this animal, which, with the exception of one placed in the Smithsonian collection by Prof. Hayden, in 1860, are the first individuals of the species that have been brought before the scientific world. One very curious fact relating to Baird's rabbit is, that all the males have teats, and take part in suckling the young! Four out of the five specimens were adult males, and they all had large teats full of milk; and the hair around the nipple was wet, and stuck to it, showing that, when taken, they had just been engaged in nursing their young. As no females were found, Mr. Merriam thought this might be an hermaphrodite form; so he and Dr. Josiah Curtis dissected a large male, which was found to contain the usual male genital organs, but no uterus, ovaries, or other female organs. Another old male was dissected, with the same result.

Steel Bars for Bells.—An item has long been on its travels both in England and this country, announcing steel bars as a cheap and efficient substitute for bells in churches, factories, etc. To numerous letters of inquiry on the subject, we have been obliged to reply that we knew nothing of the kind either here or abroad. The London *Builder*, having been similarly questioned, has lately taken the trouble to examine the matter, and the following is the only foundation for the statement it has been able to discover:

On the 28th of July, 1873, a provisional specification only was granted by the English Patent-Office to Ferdinand Rahles and James Dixon Mackenzie, for new or improved bells, or bar-bells and apparatus connected therewith. This invention consists of sounding instruments made from bars of steel, or other metal compositions, of a straight or curved form, producing musical notes or sounds. These bars are made of any suitable weight or dimensions, according to the power of sound desired. They are intended to be a substitute for ordinary cast bells, for use in churches or other places, and are suspended and carried in or on frames perpendicularly or otherwise, the sounds being produced from them by concussion with mallets or other mechanical contrivances worked either by manual or other mechanical agency.

Each bar is struck by a mallet or mallets, and motion is communicated to the arms of the mallets by cords or other suitable attachments to the outer end of the arms, and passing down the tower or other place where the bars are fitted. The inventors of the above not having perfected the patent, any one is now at liberty to carry out the design.

The Transmutation of Species.—A friend in Hamilton, N. Y., kindly sends us the following extract, translated from the German of Carus Sterne; the passage occurs in the course of an interesting essay by that writer on "The Radish:" "The more strict among modern botanists," says Sterne, "refuse to place the charlock (*Hederich*) in the same species with the radish. In general character, there is a considerable resemblance between the two; but this proves little, since most specimens of the *Crucifera* family show a strong habitual resemblance. In the fruit, which in this family furnishes almost the only distinguishing feature, a great difference exists. The charlock bears fruit from one and a half to two inches long, thin, necklace-like, with a decided beak, separating crosswise, at maturity, into joints, each joint containing a shining seed. The radish, on the contrary, bears a plump, coniform pod, almost without a beak; and, at maturity, it splits lengthwise. The seeds are not shining, but wrinkled. So great is this difference, that many modern botanists have departed from Linnæus's classification of these plants as two varieties of the same species — *Raphanus raphanistrum* and *R. sativus*—and have made of the former a separate species, *Raphanistrum.*

"But two summers ago, Prof. H. Hoffmann discovered that Linnæus was right. For four years he had cultivated charlock in the Botanic Gardens at Giessen, and at last had the joy of finding, amid many transition forms, genuine radish-fruit, upon two charlock-plants. As hybridization with radish was out of the question, this was held to be a demonstration of the specific identity of these two plants. This is a highly-important and instructive discovery: it is a sort of 'leap' which, morphologically considered, seems greater perhaps than that from man to ape.

"Those," continues the author, "who wish to know nothing of the transmutation of species, but who hold that all things have continued from eternity as they were created, will conclude that the devil himself has here stuck a pair of radish-pods in Prof. Hoffmann's charlocks, simply to lead men astray. Should the observation be verified (of which we have no doubt), and if we have not here to deal merely with a mixture of pollens, as in the supposed transformation of *Ægilops* into wheat, then will the radish become one of the strongest arguments for the Darwinian theory."

The Corrosion of Glass.—A correspondent sends the following on the corrosion of glass, by what would otherwise be considered a bland and harmless liquid:

"My daughters sometimes make a mantel ornament by half filling a glass tumbler with water, placing a little cotton on the water, and then laying some grains of wheat, oats, or flax-seed on the cotton. A small field of grain is soon the result; but invariably the glass is corroded in such a way as to look blurred and dim. In one or two cases, a bouquet of flowers cut from the stems in the yard, and placed in a glass tumbler, and accidentally left standing a few days, produced the same effect as the growing grain. After spoiling quite a number of glasses in this way — some of fine cut glass—the practice was abandoned as unprofitable in general. In one of the *corroded* tumblers there is now growing a fine patch of wheat. Your article on the action of mucilage brought this matter up in conversation. Whether others have noticed this fact is unknown to me; and, if not, this may be an item of news to them."

A Human Automaton.— The following particulars with regard to the case of the French sergeant, quoted in Prof. Huxley's Belfast letter, we find in the *Lancet.* During the late war between France and Germany, two and a half inches of the left parietal bone of his skull was carried off by a bullet, laying bare the brain on that side. The resulting paralysis of the members of the right side of the body having yielded to treatment, and the wound in the skull having commenced to heal, the man began to resume his usual occupation of a singer in *cafés*. Soon, however, he was seized with nervous symptoms of an extraordinary nature, lasting from twenty-four to forty-eight hours, and he returned to the hospital. When in his fit, he is totally insensible to pain, but his will may be influenced by contact with exterior objects. When set upon his feet he marches on quite steadily, with fixed eyes, but utters no word, nor knows what is going on about him. If he meets with an obstacle in his way, he tries to make out what it is by feeling, and then attempts to get out of its way. If a pen be put in his hand he will fumble about for ink and paper, and, if he gets these, will write a very sensible business letter. Give him cigarette-paper, and he will take out his tobacco-pouch and make a cigarette, and light it with a match from his own box. If a by-stander extinguish the match, he will strike another; and so on till his supply is exhausted. But, if a lighted match be put into his hand, he will not use it, and will let it burn between his fingers. No matter what his tobacco-pouch is filled with, he will roll his cigarette all the same, and smoke it. When the fit is past, he has no recollection of what has been said or done.

Cremation among North American Indians.—Dr. John L. Le Conte read a paper at the Hartford meeting of the American Association, giving an account of a ceremonial of cremation among the Cocopa Indians of California, of which he was an eye-witness. A shallow ditch was dug, in which logs of the mesquite, a hard, dense wood which makes a very hot fire, with but little flame or smoke, were laid. The body was placed on the logs, with some smaller fagots piled upon it, aud a few of the personal effects of the deceased were also added. Fire was then applied to the pile. At this point the doctor was about to retire, when one of the Indians told him to remain, as there was yet something to be seen. An old man then advanced from the assemblage with a long, pointed stick in his hand. With this he removed the eyes, holding them successively on the point of the stick in the direction of the sun, repeating at the same time words which were represented as being a prayer for the soul of the deceased. After this more fagots were heaped on the fire, which was kept up for three or four hours longer. When the fire has gone out, it is the custom to gather the fragments of bone and put them in a terra-cotta vase, which is kept under the care of the family. Dr. Le Conte was unable to say whether the custom of burning the dead was a general one or not, among this or other California tribes of Indians, but thought it desirable to gather up and put on record whatever evidence there might be on so interesting a subject, before the total disappearance of these people put the settlement of the question beyond our reach.

House-heating in Sweden.—A traveler in Sweden contributes to one of the newspapers an account of the very economical mode of house-warming adopted in that country. The *kakelung*, or Swedish stove, is a great oven of masonry covered with porcelain plates, having usually five flues, through which the gases of combustion must pass up and down, a distance of thirty to fifty, or even sixty feet, before escaping iuto the air. The general principle of their operation is to provide enough material to absorb all the heat from the fire; to conduct the gases through these long flues till their temperature has fallen to a point that no longer gives off heat. The quantity of the material in the kakelung is so great that the temperature from one firing will not raise the temperature of any part so much that the hands cannot be held upon the outside. Two hours after a fire is made, and after the wood-fuel has burned up, and the flue been closed, the kakelung begins to get warm on the outside, the light porcelain plates give off their moderate warmth to the atmosphere in the room, and ten hours later there will not be much difference in the temperature of the stove or of the room. A kakelung, instead of being au unsightly obstruction, is an ornamental piece of furniture. A door opens into it in front, where, in a kind of closet with iron shelves, food can be kept warm, or warmed. Baking can be done in the furnace for hours after the fire has been burned out.

How Suctorial Insects feed.—It is commonly supposed that dipterous, or two-winged insects, never eat the pollen of plants, their mouths being destitute of mandibles, and fitted only with a tube, or proboscis, for sucking up juices. That this statement does not hold good for all insects belonging to this order, is shown from observations lately made by Alfred W. Bennett. This distinguished entomologist has found that at least insects of the family *Syrphidæ* (hoverer-flies) eat the pollen of plants. He has examined, under the microscope, the contents of the abdomen of two species of syrphidæ, which he found to be colored a bright orange, owing to the presence of enormous quantities of aster-pollen. That the grains of pollen are not accidentally taken up, but form an actual article of food, is proved by their being found in every stage of digestion, the fluid contents of the grains being apparently the nutritive substance, and the skins being ultimately excreted. During the last spring, Mr. Bennett captured *Eristalis tenax* (the drone-fly) on the flowers of the sloe. The abdomen of the insect was full of pollen-grains, belonging to at least three kinds of plants—sloe, dandelion, and probably fuchsia.

Oxidation retarded by Molecular Vibrations.—A paper was read, at the American Association meeting, on "Mechanical Vibration retarding Rust," by Prof. S. S. Haldeman. The iron track of a railroad is but little subject to oxidation, while iron rails piled alongside quickly rust. If traffic be suspended on a railroad for a day, and, in the mean time, a rain of some hours' duration fall on the rails, they soon show signs of rust. From these facts Prof. Haldeman argues that, in chemical combination, mechanical vibrations may interfere with the molecular arrangement of the elements. He would, however, have these casual observations submitted to the test of experiment. A discussion followed, in the course of which it was suggested that possibly the oil employed upon locomotives might be more or less spread in a thin film over rails in use, and thus prevent their oxidation. This view met with no favor. Prof. Van der Weyde was quite certain that the suggestion of Prof. Haldeman had reference to a fact in physics. Molecular vibrations do undoubtedly tend to prevent rust: a saw hung up unused would soon grow rusty, whereas if used it would keep bright; and the observation is universal with regard to mechanical tools.

The Metric System of Weights and Measures.—On the last day of the Hartford meeting of the American Association, President Barnard, of Columbia College, delivered an address on the "Metric System." He predicted that the metric system will become the sole system of weights and measures in use throughout civilized nations before the year 1900. In France, Holland, Belgium, Spain, Portugal, Italy, Switzerland, the German Empire—in fact, all Europe, except Scandinavian countries and England, and in all America, except the United States, the metric system has been adopted. Even in the Indian empire of Great Britain the metric system has been adopted, and that system has been legalized, though not yet adopted, in Great Britain and here. At the Vienna Metrological Congress, every delegate, though representing nearly every country on the civilized globe, voted for the metric system.

NOTES.

The American Society of Civil Engineers have appointed a committee to report on plans for—1. The best means of rapid passenger transit; and, 2. The best and cheapest method of delivering, storing, and distributing goods and freight in and about the city of New York. The society ask for suggestions from all civil engineers, and others who may be possessed of any information touching the subject of their investigations. The secretary of the society is G. Leverich, and his address is 63 William Street.

Last December a telegram was sent from New York to London, and an answer received in 30 minutes actual time. The distances traversed were as follows: from New York to Heart's Content, N. F., 1,300 miles; cable, 2,000; Valentia to London, 300 miles. Each of the telegrams, therefore, traveled 3,600 miles, and passed through the hands of 18 persons.

An international exhibition has positively been decided upon in China, and a committee formed at Shanghai for the purpose of organizing it, the English consul being its president. All charges of transport will be defrayed by the committee. The *Academy*, our authority for the above statement, does not say what part the Chinese Government are to take in this important enterprise.

In his address at the Breslau Congress of German Naturalists and Physicians, Virchow spoke of the miracles said to have been performed at the scenes of many of the recent Catholic pilgrimages. He had not, he said, visited Louise Lateau, the Belgian *stigmatisée.* An examination, he observed, would have led to no useful result, except under certain conditions laid down by himself, and rejected by the other side.

Dr. Adolf Meyer has collected in New Guinea 63 different specimens of animals belonging to the orders reptilia and batrachia, of which 34 are new to science. The predominant types are Australian.

In Prince William County, Virginia, according to the Monthly Report of the Department of Agriculture, wasps were last summer observed destroying the Colorado beetle very rapidly. From the same authority we learn that in Whiteside County, Illinois, a new beetle, undescribed, attacked the larvæ of the Colorado beetle, "thrusting it through the body with its beak and killing it instantly."

The operations of the Irish Peat Fuel Company, though prosecuted under the most unfavorable circumstances during the winter months, have given very satisfactory results. By a mixture of the lighter and heavier portions of the peat, a fuel has been obtained having a density about 15 per cent. that of coal. This peat-fuel is also full of gas, burns with a bright, hot flame, and produces a hard cinder, which remains red throughout until it is entirely consumed. The density of the fuel, it is thought, will render it suitable for smelting-purposes; and, if so, it would be possible to produce a superior quality of iron from the Irish ores, which are at present comparatively valueless, owing to the want of a suitable fuel to smelt them.

The construction of the Panama Railroad cost 81,000 human lives, destroyed by malaria; this death-rate is equal to one man per yard of the track.

During six hours of July 29th last, rain fell in Chowan County, North Carolina, to the depth of twelve inches.

At the request of Mr. A. W. Sheldon, general agent of the Prison Association of New York, the Commissioners of Charities and Correction have had a room set apart for a library in Blackwell's Island Penitentiary. The library-room is suitably fitted up for its destined use, and the Association has already made a liberal donation of books. We are requested to state that contributions of books, magazines, etc., for the above library will be received at the office of the Association, No. 19 Centre Street.

A Microscopical Society has recently been founded in Memphis, Tennessee. Its membership is already numerous, and its regular semi-monthly meetings are characterized by a large attendance of members, as also by an evident determination to forward the cause of microscopic research by hard, honest work. At the second October meeting of the society, A. F. Dodd read a paper on infusorial life, illustrated by drawings from life of a large number of specimens

La Nature vouches for the absolute correctness of the following figures, showing the consumption of tobacco in France in 1873: Smoking-tobacco, 40,000,000 lbs.; cigars, 7,716,976 lbs. (925,000,000 cigars); snuff, 16,536,375 lbs.; chewing-tobacco, 1,433,152 lbs.; "carotte," a sort of tobacco used (mostly in Brittany) for smoking, chewing, and snuffing, 992,182 lbs. Total, over 66,500,000 lbs. The total revenue derived by the state from this manufacture was last year 294,000,000 francs. Paris has 1,200 tobacconists' shops.

After the death of Boerhaave, the most celebrated physician of the eighteenth century, there was found among his books a volume sumptuously bound, in which were written down, he used to say, all the secrets of physic. All the pages were blank, except the frontispiece, on which he had written in his best hand this sentence: "Keep the head cool, the feet warm, and the bowels open."

The annual report of the treasurer of the French Association for the Advancement of Science shows that this, the youngest of the national scientific institutions, stands upon a sound financial basis. At the close of 1873 it had a funded capital of about 166,000 francs, yielding an income of over 9,000 francs. This income, together with the subscriptions of members, brought the total receipts of 1873 to about 30,000 francs. This money is judiciously expended in giving encouragement to original research.

Another Jesse Pomeroy has appeared in Chico, California. A boy in that town has developed an uncontrollable propensity for injuring with stones, clubs, etc., all the little children that he meets. He has been lodged in jail, and now threatens to kill a number of his companions as soon as he is released.

PROFESSOR JEFFRIES WYMAN.

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CRYSTALLINE AND MOLECULAR FORCES.[1]

By Prof. JOHN TYNDALL, LL. D., F. R. S.

A FEW years ago I paid a visit to a large school in the country, and was asked by the principal to give a lesson to one of his classes. I agreed to do so, provided he would let me have the youngest boys in his school. To this he willingly assented; and, after casting about in my mind as to what could be said to the little fellows, I went to a village hard by and bought a quantity of sugar-candy. This was my only teaching apparatus. When the time for assembling the class had arrived I began by describing the way in which sugar-candy and other artificial crystals were formed, and tried to place vividly before their young minds the architectural process by which the crystals were built up. They listened to me with the most eager interest. I examined the crystal before them, and, when they found that in a certain direction it could be split into thin laminæ with shining surfaces of cleavage, their joy was at its height. They had no notion that the thing they had been crunching and sucking all their lives embraced so many hidden points of beauty. At the end of the lesson I emptied my pockets among the class, and permitted them to experiment upon the sugar-candy in the usual way.

When asked to come here and lend a helping hand in what I believe to be a truly good work (though hard pressed by other duties), I could not refuse the invitation.

I know not whether this great assembly will deem it an impertinence on my part if I seek to instruct them for an hour or so on the subject chosen for my little boys. In doing so I run the imminent risk of being wearisome as well as impertinent, while laboring under the further disadvantage of not being able to make matters pleasant at the conclusion of the lecture by the process adopted at the end of my lesson to the boys.

[1] A Lecture, delivered in the Free-Trade Hall, Manchester, on Wednesday, October 28, 1874.

We are to consider this evening the phenomena of crystallization; but, in order to trace out the genesis of the notions now entertained upon the subject, we have to go a long way back.

In the drawing of a bow, the darting of a javelin, the throwing of a stone, in the lifting of burdens, and in personal combats, even savage man became acquainted with the operation of *force*. His first efforts were directed toward securing food and shelter; but ages of discipline—during which his force was directed against Nature, against his prey, and against his fellow-man—taught him foresight. He laid by at the proper season stores of food, and thus obtained time to look about him, and become an observer and inquirer. He discovered two things, which now more specially interest us, and sent down to us the knowledge of his discovery. He found that a certain resin dropped from the amber-tree possessed, when rubbed, the power of drawing light bodies to itself, and of causing them to cling to it; and he also found that a particular kind of stone exerted a similar power over a particular kind of metal. I allude, of course, to the loadstone, or natural magnet, and its power to attract particles of iron. Previous experience had enabled our early inquirer to distinguish between a push and a pull. In fact, muscular efforts might be divided into pushes and pulls. Augmented experience showed him that in the case of the magnet, pulls and pushes—attractions and repulsions—were also exerted; and, by a kind of poetic transfer, he applied to things external to himself the conceptions derived from the exercise of his own muscular power. The pushes and pulls of the magnet and of the rubbed amber were to him also force.

In the time of the great Lord Bacon, the margin of these pushes and pulls was vastly extended by Dr. Gilbert, a man probably of firmer fibre, and of finer insight, than Bacon himself; who, moreover, was one of the earliest to enter upon that career of severe experimental research which has rendered our science almost as stable as the system of nature which it professes to explain. Gilbert proved that a multitude of other bodies, when rubbed, exerted the power which thousands of years previously had been observed in amber. In this way the notion of attraction and repulsion in external Nature was rendered familiar. It was a matter of experience that bodies between which no visible link or connection existed, possessed the power of acting upon each other; and the action came to be technically called "action at a distance."

But out of experience in science there always grows something finer than mere experience. Experience, in fact, only furnishes the soil for plants of higher growth; and this observation of action at a distance furnished material for speculation upon the largest of all problems. Bodies were observed to fall to the earth. Why should they do so? The earth was proved to roll round the sun; and the moon to roll round the earth. Why should they do so? What prevents them from flying straight off into space? Supposing it to be ascertained that from a part of the earth's rocky crust a firmly-fixed and tightly-stretched chain started toward the sun, we might be inclined to conclude that the earth is held in its orbit by the chain—that the sun twirls the earth around him as a boy twirls a bullet at the end of a string round his head. "But why should the chain be needed?" asks the speculative mind. "It is a fact of experience that bodies can attract each other at a distance, and without the intervention of any chain. Why should not the sun and earth so attract each other? and why should not the fall of bodies from a height be the result of their attraction by the earth?" Here, then, we have one of those higher thoughts of speculation which grow out of the fruitful soil of observation. Having started with the savage and his sensations of muscular force, we pass on to the observation of force exerted between a magnet and rubbed amber, and the bodies which they attract, and rise by an unbroken growth of ideas to a conception of the force by which sun and planets are held together.

This idea of attraction between sun and planets had become a familiar one in the time of Newton. He set himself to examine the attraction, and here, as elsewhere, we find the speculative mind falling back for its materials upon experience. It had been observed, in the case of magnetic and electric bodies, that the nearer they were brought together the stronger was the force exerted between them; while, by increasing the distance, the force diminished until it became insensible. Hence the inference that the assumed pull between the earth and the sun would be influenced by their distance asunder. Guesses had been made as to the exact manner in which the force varied with the distance; but, in the case of Newton, the guess was supplemented by being brought to the severe test of experiment and calculation. Comparing the pull of the earth upon a body close to its surface, with its pull upon the moon, 240,000 miles away, Newton rigidly established the law of variation with the distance, thus placing in our hands a principle which enables us to determine the date of astronomical events in the far historic past or in the distant future.

But, on his way to this great result, Newton found room in his ample mind for other conceptions, some of which, indeed, constituted the necessary stepping-stones to his result. The one which here concerns us most is this: Newton proved that not only did the sun attract the earth, and the earth attract the sun, *as a whole*, but that every particle of the sun attracts every particle of the earth, and the reverse. His conclusion was, that the attraction of the masses was simply the sum of the attractions of their constituent particles.

This result seems so obvious that you will perhaps wonder at my dwelling upon it; but it really marks a turning-point in our notions of force. You have probably heard of late of certain disturbers of the public peace named Democritus, Epicurus, and Lucretius. These men adopted, developed, and diffused the dangerous doctrine of atoms and molecules which found its consummation in this city of Manchester at the hands of the immortal John Dalton. Now, the grand old pagans whom I have named, and their followers up to the time of Newton, had pictured their atoms as falling and flying through space, hitting each other, and clinging together by imaginary claws and hooks. They entirely missed the central idea that the atoms and molecules could come together, not by being fortuitously knocked against each other, but by their own mutual attractions. This is one of the great steps taken by Newton. He familiarized the world with the conception of *molecular force.*

But the matter does not end here; experience had given us the key to further mysteries. In the case of electricity and magnetism a double exercise of force had been observed—repulsion had been always seen to accompany attraction. Electricity and magnetism were examples of what are called *polar forces;* and, in the case of magnetism, experience itself pushed the mind irresistibly beyond the bounds of experience, compelling it to conclude that the polarity of the magnet was resident in its molecules. I hold a strip of steel by its centre, between my finger and thumb. One half of the strip attracts, and the other half repels the north end of a magnetic needle. I break the strip in the middle, and what occurs? The middle point or equator of the magnetism has shifted to the centre of the new strip. This half, which a moment ago attracted throughout its entire length the north pole of a magnetic needle, is now divided into two new halves, one of which wholly attracts, and the other of which wholly repels, the north pole of the needle. Thus the half when broken off proves to be as perfect a magnet as the whole. You may break this half, and go on breaking till further breaking becomes impossible through the very smallness of the fragments; still you find at the end that the smallest fragment is endowed with two poles, and is, therefore, a perfect magnet. But you cannot stop here: you *imagine* where you cannot *experiment;* and reach the conclusion entertained by all scientific men, that the magnet which you can see and feel is an assemblage of molecular magnets which you cannot see and feel, but which must be intellectually discerned.

I shall endeavor to show you some of the actions of this polar force, at the same time asking you to remember that my main object here to-night is to show you the growth of scientific ideas, and to illustrate the manner in which the scientific investigator uses his thoughts and his hands in the investigation of Nature.

Scientific ideas, as already stated, spring out of experience, but they extend beyond the boundary of experience. And, indeed, in this power of ideal extension consists for the most part the differences between scientific men. The man who cannot break the bounds of experience, but holds on to the region of sensible facts, may be an excellent observer, but he is no philosopher, and can never reach those principles which bind the facts of science together. True, the speculative faculty may be abused like all good things, but it is not men of science that are most likely to abuse it. When he accounted for the heat of chemical combination by referring it to the clash of atoms *falling* together, a townsman of your own described an image presented to his mind but entirely beyond the reach of his senses. It was, however, an image out of which grew memorable consequences; among others this one of a personal nature: The walls of this Free-Trade Hall, or rather its predecessor, have rung with the speeches of Cobden, and Bright, and Wilson. But, at the time when their words rolled round the world, a scientific worker was silently and studiously engaged in your city grappling with the problem how out of heat is extracted mechanical force, and by implication with far higher problems. He grappled with it successfully, bringing it into the full light of experimental demonstration. And I venture to affirm that in the coming time, not even the great orators and politicians just named, not even the greatest of your manufacturing princes, will enjoy a purer, a more permanent or enviable fame—there is not a man among them of whom Manchester will be more justly proud than of her modest brewer, but renowned scientific worker, James Prescott Joule.

You will pardon this momentary deflection from my subject. We have now to track still further the growth of our notions of force. We have learned that magnetism is a polar force; and experience also hints that a force of this kind may exert a certain structural power. It is known, for example, that iron-filings strewed round a magnet arrange themselves in definite lines, called, by some, "magnetic curves," and, by Faraday, "lines of magnetic force." In these observed results of magnetic polarity we find the material for speculation, in an apparently distant field. You can readily make an experiment or two for yourselves with any magnet. My excellent assistant, Mr. Cottrell, places two magnets before me, and over them a sheet of paper. Scattering iron-filings over the paper and tapping it, the filings arrange themselves in a singular manner. There is a polar force here in action, and every particle of iron on the paper responds to that polar force, and the consequence is, a certain structural arrangement—if I may use the term—of the iron-filings. Here is a fact of experience which, as you will see immediately, furnishes further material for the mind to operate upon, rendering it possible to attain intellectual repose and satisfaction while speculating upon apparently remote phenomena.

You cannot enter a quarry and scrutinize the texture of the rocks without seeing that it is not perfectly homogeneous. If the quarry be of granite, you find the rocks to be an agglomeration of crystals, of quartz, mica, and felspar. If the rocks be sedimentary, you find them, for the most part, composed of crystalline particles derived from older rocks. If the quarry be marble, you find the fracture of the rocks to be what is called crystalline fracture. These crystals are, in fact, everywhere. If you break a sugar-loaf, you find the surface of fracture to be composed of small, shining, crystalline surfaces. In the fracture of cast-iron you notice the same thing; and next to his great object of squeezing out the entangled gas from his molten metal, another object of your celebrated townsman, Sir Joseph Whitworth, when he subsequently kneads his masses of white-hot iron as if they were so much dough, is to abolish this crystalline structure. The shining surfaces observed in the case of crystalline fracture are surfaces of weak cohesion; and, when you come to examine large and well-developed crystals, you soon learn why they are so. I try the crystal of sugar referred to at the beginning of this lecture in various directions with the edge of my knife, and find it obdurate; but I at length come upon a direction in which it splits clearly before the knife, revealing two shining surfaces of cleavage. Such surfaces are seen when you break cast-iron, and the metal is strengthened by their abolition. Other crystals split far more easily than the sugar.

In the course of scientific investigation, then, as I have tried to impress upon you, we make continual incursions from a physical world where we observe facts, into a super or sub-physical world, where the facts elude all observation, and we are thrown back upon the picturing power of the mind. By the agreement or disagreement of our picture with subsequent observation, it must stand or fall. If it represent a reality, it abides with us; if not, it fades like an unfixed photograph in the presence of subsequent light. Let me illustrate this. You know how very easy it is to cleave slate-rock. You know that Snowdon, Honister Crag, and other hills of Wales and Cumberland, may be thus cloven from crown to base. How was the cleavage produced? By simple bedding or stratification, you may answer. But the answer would not be correct; for, as Henslow and Sedgwick showed, the cleavage often cuts the bedding at a high angle. Well, here, as in other cases, the mind, endeavoring to find a cause, passed from the world of fact to the world of imagination, and it was assumed that slaty cleavage, like crystalline cleavage, was produced by polar forces. And, indeed, an interesting experiment of Mr. Justice Grove could be called upon to support this view. I have here, in a cylinder with glass ends, a fine magnetic mud, consisting of small particles of oxide of iron suspended in water. You can render those suspended particles polar by sending round the cylinder an electric current; and their subsequent action may be rendered evident. At present they are promiscuously strewed in the liquid. But the moment the current passes they all set their lengths parallel to a common direction. Before the current passes, the strongest beam of light can hardly struggle through the turbid medium. But, the moment it passes, light is seen to flash out upon the screen. Now, if you imagine the mud of slate-rocks to have been thus acted on, so as to place its particles with their lengths in a common direction, such elongated and flat particles would, when solidified, certainly produce a cleavage.

Plausible as this is, it is not the proper explanation, the cleavage of the slate-rocks being demonstrably not crystalline, but, as shown by Sharpe, Sorby, Haughton, and myself, due to pressure.

The outward forms of these crystals are various and beautiful. A quartz-crystal, for example, is a six-sided prism, capped at each end by six-sided pyramids. Rock-salt, with which your neighbors in Cheshire are so well acquainted, crystallizes in cubes; and it can be cloven into cubes until you cease to be able to cleave further for the very smallness of the masses. Rock-salt is thus proved to have three planes of cleavage at right angles to each other. Iceland spar has also three planes of cleavage, but they are oblique instead of rectangular, the crystal being, therefore, a rhomb instead of a cube. Various crystals, moreover, cleave with different facilities in different directions. A plane of principal cleavage exists in these crystals, and is accompanied by other planes, sometimes of equal, sometimes of unequal value as regards ease of cleavage. Heavy spar, for example, cleaves into prisms, with a rhombus or diamond-shaped figure for a base. It cleaves with greatest ease across the axis of the prism, the other two cleavages having equal values in this respect. Selenite cleaves with extreme facility in one direction, and with unequal facilities in two other directions.

Looking at these beautiful edifices and their internal structure, the pondering mind has submitted to it the question, How have these crystals been built up? What is the origin of this crystalline architecture? Without crossing the boundary of experience, we can make no attempt to answer this question. We have obtained clear conceptions of polar force; we know that polar force may be resident in the molecules or smallest particles of matter—we know that by the play of this force structural arrangement is possible. What, in relation to our present question, is the natural action of a mind furnished with this knowledge? Why, it is compelled by its bias toward unity of principle to transcend experience, and endow the atoms and molecules of which these crystals are built with definite poles, whence issue attractions and repulsions for other poles. In virtue of this attraction and repulsion some poles are drawn together, some retreat from each other; atom is thus added to atom, and molecule to molecule, not boisterously or fortuitously, but silently and symmetrically, and in accordance with laws more rigid than those which guide a human builder when he places his bricks and stones together. From this play of invisible particles we see finally growing up before our eyes these exquisite structures, to which we give the name of crystals.

In the specimens hitherto placed before you the work of the atomic architect has been completed; but you shall see him at work. In the first place, however, I will take one of his most familiar edifices, and try to pull it to pieces before your eyes. For this purpose I choose ordinary ice, which is our commonest crystalline body. The agent to be employed in taking down the molecules of the ice is a beam of heat. Sent skillfully through the crystal, the beam selects certain points for attack; round about those points it works silently, taking down the crystalline edifice, and reducing to the freedom of liquidity molecules which had been previously locked in a firm, solid embrace. The liquefied spaces are rendered visible by strong illumination, and throwing their magnified images on a screen. Starting from numerous points in the ice we have expanding flowers, each with six petals, growing larger and larger, and assuming, as they do so, beautifully crimped borders; showing, if I might use such terms, the pains, and skill, and exquisite sense of the beautiful, displayed by Nature in the formation of a common block of ice.

Here we have a process of demolition, which, however, clearly reveals the reverse process of erection. I wish, however, to show you the molecules in the act of following their architectural instincts, and building themselves together. You know how alum, and nitre, and sugar crystals, are formed. The substance to be crystallized is dissolved in a liquid, and the liquid is permitted to evaporate. The solution soon becomes supersaturated, for none of the solid is carried away by evaporation; and then the molecules, no longer able to enjoy the freedom of liquidity, close together and form crystals. My object now is to make this process rapid enough to enable you to see it, and still not too rapid to be followed by the eye. For this purpose a powerful solar microscope and an intense source of light are needed. They are both here. Pouring over a clean plate of glass a solution of sal-ammonia, and placing the glass on its edge, the excess of the liquid flows away, but a film clings to the glass. The beam employed to illuminate this film hastens its evaporation, and brings it rapidly into a state of supersaturation; and now you see the orderly progress of the crystallization over the entire screen. You may produce something similar to this if you breathe upon the frost-ferns which overspread your window-panes in the winter, and permit the liquid to recrystallize. It runs, as if alive, into the most beautiful forms.

In this case the crystallizing force is hampered by the adhesion of the liquid to the glass; nevertheless, the play of power is strikingly beautiful. In the next example our liquid will not be so much troubled by its adhesion, for we shall liberate our atoms at a distance from the surface of the glass. Sending an electric current through water, we decompose the liquid, and the bubbles of the constituent gases rise before your eyes. Sending the same current through a solution of acetate of lead, the lead is liberated, and its free atoms build themselves together to crystals of marvelous beauty. They grow before you like sprouting ferns, exhibiting forms as wonderful as if they had been produced by the play of vitality itself. I have seen these things hundreds of times, but I never look at them without wonder. And, if you allow me a moment's diversion, I would say that I have stood in the spring-time and looked upon the sprouting foliage, the grass, and the flowers, and the general joy of opening life; and in my ignorance of it all I have asked myself whether there is no power, being, or thing, in the universe whose knowledge of that of which I am so ignorant is greater than mine. I have asked myself, Can it be possible that man's knowledge is the greatest knowledge—that man's life is the highest life? My friends, the profession of that atheism with which I am sometimes so lightly charged would, in my case, be an impossible answer to this question: only slightly preferable to that fierce and distorted theism which I have had lately reason to know still reigns rampant in some minds as the survival of a more ferocious age.

Everywhere throughout our planet we notice this tendency of the ultimate particles of matter to run into symmetric forms. The very molecules seem instinct with a desire for union and growth. How far does this play of molecular power depend? Does it give us the movement of the sap in trees? Assuredly it does. Does it give us, in ourselves, the warmth of the body and the circulation of the blood, and all that thereon depend? We are here upon the edge of a battle-field which I do not intend to enter to-night; from which, indeed, I have just escaped bespattered and begrimed, but without much loss of heart or hope. It only remains for me to briefly indicate the positions of the opposing hosts. From the processes of crystallization which you have just seen, you pass by almost imperceptible gradations to the lowest vegetable organisms, and from these through higher ones up to the highest. The opposition to which I have referred is: that whereas one class of thinkers regard the observed advance from the crystalline through the vegetable and animal worlds as an unbroken process of natural growth, thus grasping the world, inorganic and organic, as one vast and indissolubly connected whole, the other class suppose that the passage from the inorganic to the organic required a distinct creative act, and that to produce the different forms, both in the world of fossils and in the world of living things, creative acts were also needed. If you look abroad you will find men of equal honesty, earnestness, and intelligence, taking opposite sides as regards this question. Which are right and which are wrong is, I submit, a problem for reasonable and grave discussion, and not for anger and hard names. The question cannot be solved—it cannot even be shelved—by angry abuse. Nor can it be solved by appeals to hopes and fears—to what we lose or gain here or hereafter by joining the one or the other side. The bribe of eternity itself, were it possible to offer it, could not prevent the human mind from closing with the truth. Skepticism is at the root of our fears. I mean that skepticism which holds that human nature, being essentially corrupt and vile, will go to ruin if the props of our conventional theology are not maintained. When I see an able, and in many respects courageous man, running to and fro upon the earth, and wringing his hands over the threatened loss of his ideals, I feel disposed to exhort him to cast out this skepticism, and to believe undoubtingly that in the mind of man we have the substratum of all ideals. We have there capacity which will as surely and infallibly respond to the utterances of a really living soul as string responds to string when the proper note is sounded. It is the function of the teacher of humanity to call forth this resonance of the human heart, and the possibility of doing so depends wholly and solely upon the fact that the conditions for its production are already there.

EVOLUTION IN ORNAMENT.

By CH. FRED. HARTT.

ON the two Morgan Expeditions to the Amazonas, in 1870 and 1871, there was obtained from a burial-mound on the island of Marajó, or Johannes, a lot of ancient pottery, consisting of burial-urns, idols, utensils of various kinds, personal ornaments, etc., many of which were richly ornamented with *grecques*, and scrolled borders of a very high order of development. The resemblance borne by some of these ornaments to Old-World classic forms was very striking, and certain borders were, even in their accessories, identical with similar ornaments in Etruscan art. It has already been pointed out by Owen Jones that the so-called Greek fret has a very wide distribution, occurring not only in Egyptian and Greek art, but in that of India and China, while, in the New World, it was cultivated widely in both Americas. The distribution of these simple ornamental forms among widely-separated savage tribes renders it extremely unlikely that they should have all been derived from a common source, and their independent origin is all the more probable, since it has been conclusively shown that identical myths, religious ideas, manners and customs, found in different parts of the earth, have often originated independently of one another. Yet, while it is quite easy to understand how pottery might be invented by two different tribes, how is it possible that the same series of ornamental forms should arise among several independent and disconnected peoples? To the solution of this question I have addressed myself, and in this paper I propose to give, in a very condensed form, some of the more important results of my studies.[1]

[1] In my volume on the "Antiquities of Brazil," now nearly ready for the press, I shall, in connection with an analysis of the ornaments of the Marajó pottery, treat of this subject much more thoroughly.

Purely æsthetic decorative art has had its origin in the attempt to please the eye by lines and colors, just as music has originated in the attempt to give pleasure to the ear by a rhythmic series of sounds. Imitative decorative art appeals to the understanding as well as to the feelings; it is a song with words, but mere æsthetic ornament is visible music without words, and it is to this latter division of ornament that I shall principally invite your attention.

Color and form in ornament are so very different in their functions that they must be considered apart. Of the two, form is the more important element, and, in the following discussion, color will be left out of consideration.

The secret of the pleasant effect produced upon us by beautiful lines is, I believe, to be found in the structure of the eye itself, and I shall attempt to show that a line is beautiful, not because of any inherent quality of its own, but, primarily, because of the pleasure we take in making the muscular movements necessary to run over it with the eye, though, through education, we may afterward come to recognize, at a glance, and get the full effect of a form that has once given us pleasure; just as in music, the first few notes of an *aria* may be sufficient to recall the general effect of the complete composition.

When I look out of my window, the image of a very large tract falls upon my retina. I see at once a multitude of houses, and the infinitude of objects that go to make up the picture, and apparently I see every thing distinctly, but this is really far from being the case. If I look suddenly out at a landscape that I have never seen before, and fix my gaze upon a church-spire for a few moments, the image of the landscape falls immovably upon the retina; but, if I now suddenly withdraw and try to reproduce by sketch or writing what I have seen, I shall find myself totally unable. I have only an indistinct impression of the church-spire and perhaps of a few prominent objects in its immediate vicinity. I have *seen* the landscape, but I have not *observed* it.[1] Now let me return, paper in hand, to sketch the same landscape. Instead of fixing my eye immovably upon one point, I deliberately run it over the leading lines of the view, and then trace lines upon the paper that produce the same effect upon my eye as those in Nature have done. My sketch will at best be imperfect, but its accuracy will be in proportion to the care with which I have examined the outlines in the landscape. In observing an object, we do not then look fixedly at it—*we run the eye* over it. Let us see what this means.

The retina is not in all parts equally sensitive to light, and the whole of a visual image is not distinctly perceived at once. Directly in the back part of the eye is a little spot, about a line in diameter,

[1] Observation consists in the deliberate and careful running of the eye over the features of an object so that they are distinctly seen and appreciated. It is an art only to be learned by long practice. In natural-history studies I have found drawing to be a great aid in training a student, as it affords him a test of the accuracy of his observation.

called the yellow spot of Sömmering, and to this distinct vision is limited, for we see clearly only the part of an image that falls within it. It is even doubtful whether we see at one time distinctly, or, in other words, can *observe*, more than a point in that image. If you look at the middle of this page, you really see clearly only the point directly before your eye. The rest is indistinct, and, to observe a word on another part of the page, you must move the eye so that its image may fall on the yellow spot. So in reading, you run the eye over the words, or, by moving the eye, cause their images to fall successively upon the yellow spot, and, that you may do so readily, the words are arranged in straight, horizontal lines. The eyeball, otherwise immovable, may be rotated in its socket by the action of muscles, of which, in each eye, there are four principal ones, arranged in pairs, as in Fig. 1. When *A* contracts, the pupil is turned in the direction *B A*. The pair *B A* then cause the eye to rotate from side to side, while the pair *C D* cause it to rotate in a vertical plane. By combining two contiguous muscles, as, for instance, *A* and *C*, we may move the eye obliquely in any direction. Of the oblique muscles represented in the diagram I will not here speak, as they are apparently not so important in observation as those just described.

Fig. 1.

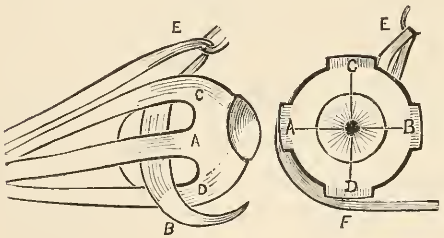
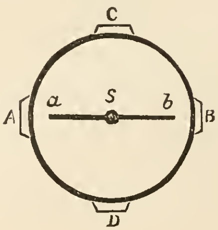


Fig. 2.



If I look at the middle of a straight, horizontal line, my head being held erect, the image of that line (*a b*, Fig. 2) will lie on the retina directly between the muscles *A B*, the central point falling in the middle of the yellow spot *S*. In running my eye over that line, I use the muscles *A B* in such a way as to draw the image through the yellow spot; and, if, in doing so, I use these muscles with perfect regularity, I say the line is straight. Perpendicular and horizontal straight lines are the more easy to examine, because their images fall directly between two opposing muscles. An oblique line is difficult to examine, and we instinctively turn the head, in order to bring it in the plane of rotation of one or the other set of muscles. In following a curved line with the eye, two muscles are used together, one contracting more rapidly than the other. A curve is therefore more difficult to observe, or run the eye over, than a straight line, and the difficulty increases with the subtileness of the curvature.[1] The æsthetic effect of curves, as of gestures, is appreciated only after long training. Their beauty is primarily due to the pleasure we take in making the muscular movements necessary to follow them, and this pleasure is strictly akin to that which we feel in tracing them with the hand, either upon paper, or simply in gesture. Pleasure-giving, graceful, muscular movements are always in curves, and their grace depends upon the subtileness of the curve.

If decorative art has had a beginning and an evolution, we should expect to find a progress from straight lines to circles, spirals, and ellipses, while more subtile curves, such as we find in Nature, would be adopted later, and this is the case, not only in the art-history of nations, but also in that of individuals, for the child must be educated not only to make, but to appreciate and enjoy beautiful lines.[2]

Man, the world over, seeks to give pleasure to the eye. He is not satisfied that an object should be useful to him; it must be at the same time beautiful; and indeed he is usually quite as anxious that it should look well, as that it should minister to his comfort. It is not enough that clothing should be warm: it must be graceful in form, and covered, more or less, with ornament. A house of logs would hold a congregation and supply all the facilities for public worship, but that is not enough. We strive to make it a palace, and enrich its walls with beautiful forms. It is verily surprising what an important element ornament is in life. Is it, then, wonderful that man, striving everywhere to please the same eye by lines, should occasionally invent, independently, similar ornamental forms, or that decorative art should, in its beginning, evolve in the same direction in different countries?

The class of ornaments I have studied with the greatest care, and, at the same time, the greatest success, is that to which the so-called "Greek fret" and "honeysuckle ornament" belong, and I now propose to discuss the question of the origin and evolution of these decorative forms, premising that other classes of ornaments may be studied in exactly the same way.

If a single straight line is pleasant to the eye, two parallel straight lines are still more so; for, in running the eye over one of the lines, we have a sort of accompaniment produced by the indistinctly-seen second line; or, in looking along an imaginary line between the two,

[1] A straight line is beautiful, because of the pleasure we derive from the perfectly even, regular use of the muscles employed in following it with the eye, a pleasure comparable to that produced by passing the hand over a smooth, flat surface, or by listening to a single musical note.

[2] In music we find also a progress from a monotonous series of effects, to those which may be represented by more and more subtile sounds. These are the curves of *melody*, of *force*, and of *acceleration*, all of which, in the evolution of music, tend to greater subtilty. I suppose that this progress from monotony to subtilty is to be explained by the unconscious desire to escape the fatigue produced by a series of too similar effects.

we get the indistinct effect of both; but it must be observed that the lines must neither be too near together, nor too far apart, else the effect of the parallelism is either impaired or entirely destroyed. The whole surface of an object, as, for instance, of a vase, may be ornamented by a great number of parallel lines, and this is often the case in primitive or rude art; but, with culture, comes the tendency to draw more or less narrow bands of lines following the most important lines of the object.

A further step is taken in the attempt to make two parallel lines more agreeable to the eye by filling in the space between them with lines, drawn in various directions, and it is in this way that the frets have originated. By drawing equidistant parallel lines directly across between the two main lines, as in Fig. 3, we make a series. This, as

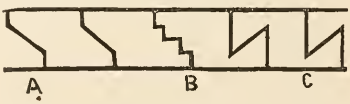
Fig. 3.

Fig. 4.

it exists in the drawing, is a series in *space*, but, as it grows up under the hand, or is examined by the eye, it is a series in *time;* and, in looking from *A* to *B*, an effect is produced upon the eye analogous to that produced upon the ear by the repetition of a musical note, with the same interval.[1] If lines be drawn only part way across, from each side alternately, as in Fig. 4, we have a sort of rhythm produced. If the lines all reach the centre, they may be, and often are, even in very savage art, connected together by twos, as in Fig. 5. This produces a series of units, each one of which is pleasant to examine with the

Fig. 5.

Fig. 6.



eye. This is the simplest form of the fret. If the lines are drawn not quite to the centre, they may be united by oblique lines, as in Fig. 6, *A*, and lines drawn past the centre may be connected in the same way, as in *C*, but neither of the resulting units is very agreeable to the eye, and such attempts are characteristic, either of a rude stage

[1] Irregularity in the interval interrupts the æsthetic effect. As each unit in the series falls on the yellow spot and is distinctly perceived, an effect is produced upon the brain which has a certain duration, gradually fading away. If the units are separated by the same intervals, these æsthetic effects will be alike; but, if they follow one another irregularly, the effect produced will be irregular, unexpected, and consequently disagreeable. The lengthening or diminution of the intervals, according to certain laws, heightens the æsthetic effect by relief from monotony; and this appears to be the least of the pleasure we derive from gradation in tint or shade.

of art, or of the work of a bungler. When the lines are not drawn to the centre, they may be joined as in *B*, and this form of fret was much cultivated in America; but it is objectionable, apparently on account of the obliquity of the units, and it is vastly inferior to the fret, Fig. 7, *A*, where lines, drawn past the middle, are united in a similar way. This last is the true Greek fret, though it occurs also in

Fig. 7.

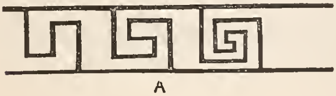
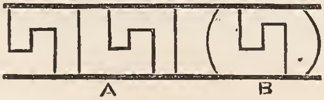


Fig. 8.



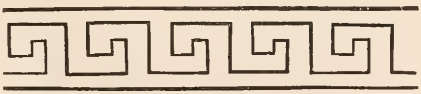
American aboriginal art. The units may be made more or less involved, as in Fig. 7, but the simple forms are the more pleasing.

I have observed that in Brazil, and elsewhere in America, the artist has often taken care to separate the units in this fret from one another, either by drawing lines between them, as in Fig. 8, *A*, or by placing them in cartouches, *B*. The addition of the line in *A* enhances the beauty of the series by breaking up the monotony and introducing a pleasing alternation. The attempt to separate the units resulted, however, in bringing about their firm union; for it was ob-

Fig. 9.

served that, by obliterating the dotted spaces in Fig. 9, the whole series could be drawn without lifting the hand, and thus arose the current fret, Fig. 10. Examples of the modification of ornaments by obliteration of parts, in this way, are common, not only in aboriginal, but also in classic and modern civilized art. The bounding lines, Fig. 10, were afterward added, and greatly heighten the beauty of

Fig. 10.



the border. The current fret is not only agreeable to run the eye over, but it is pleasant to trace with the hand. Current frets may of course be more or less involved.

Unless care is taken in drawing a current fret, one is apt to round down the angles, and, in running the eye over this ornament, there is a tendency not to follow lines down to the angles, but to swerve from one line to another, avoiding the corners—the muscular movements of the eye being such as would be necessary to follow a curve. It was soon found that frets drawn, probably at first unintentionally, with rounded corners, were pleasant to examine with the eye, and afterward they were purposely rounded down, giving rise to the beautiful linked scrolls, Fig. 11. At first, the most important part of this ornamental border was the scroll, and the connecting curve was

Fig. 11.

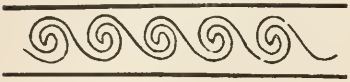


Fig. 12.

treated, so to speak, as a mere hair-line; but, by-and-by, the eye began to take more and more pleasure in following this more subtile connecting line, and it came finally to be cultivated, to the neglect of the scrolls, giving rise to the sigmoids, Fig. 12.

Some have claimed that this last ornament was originally emblematic of water. This was certainly not the case, and it never came to mean water until, having fully grown, it was recognized as resembling the curling waves of the sea. In Etruscan art we frequently find a series of little dolphins gracefully leaping over the crests, or fishes are drawn in below. Here, undoubtedly, the ornament was treated as representing water, or the sea. A host of beautiful borders grew up by combining two or more series of these scrolls and shading the spaces in various ways, but I have not time to speak of them here.

With the culture of the sigmoid curves, and the neglect of the spirals, much vacant space is left in the border which will look better if filled in with ornament.[1]

In Brazil I have found little triangles drawn in these spaces, as in Fig. 13, while exactly the same border is found in Etruscan art.

Fig. 13.

Fig. 14.

It will be observed that the sides of the little triangles are approximately parallel to the parts of the sigmoids and bounding lines to which they are adjacent, thus producing a pleasant effect on the eye. The next step in the evolution of this border consists in uniting the little triangles with the sigmoids, as in Fig. 14, and this form I have observed on a Peruvian vase.

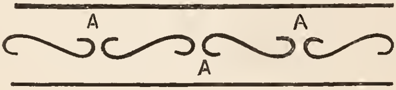
With progress in culture comes the love of variety and change. Savage music, savage art, every thing in fact in uncivilized life, is monotonous. An Amazonian Indian will listen enrapt for hours to

[1] Some writers say that a space *demands* ornament, but the demand is subjective, not objective.

the repetition of the same monotonous song, which produces on civilized ears only increasing torture. The fret is at first drawn with all its unity running in the same direction, but in course of time it is found that a change of direction not only relieves the eye but gives greater pleasure, and the series comes to be broken up into bars, alternating in direction. This is observable not only in the classic Greek frets, but also in similar ornaments in America. In the intervals between the bars a square figure is often introduced, and this, both in Greek and South-American art, sometimes contains a cross or a quatrefoil. Similar breaks were often introduced into the scroll-border, in which case the bars were separated by a figure, shaped more or less like a cross-section of a biconcave lens, Fig. 15, *A*.

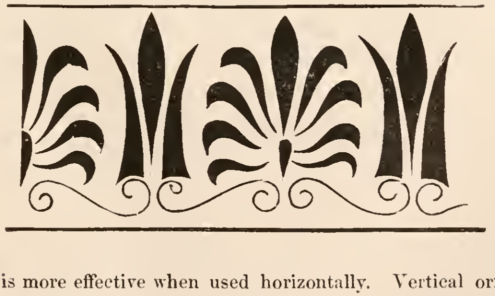
Fig. 15.

Fig. 16.



In Old-World decorative art the great step was taken when the sigmoids were separated and alternately reversed, as in Fig. 16. This gave an opportunity for the growth between the sigmoids, of accessory ornaments that developed into an infinitude of beautiful forms in Egyptian and Greek art. It will be observed that, in this series, the little volutions, Fig. 16, *A*, *A*, *A*, are turned alternately up and down. The accessory ornament corresponding to Fig. 15, *A*, has therefore a broad base upon which to expand on one side and a narrow one on the other. These accessory ornaments may be developed on both sides of the line of sigmoids, but in this case a double series is formed, and a single one is more effective.[1] In Greek art they were principally cultivated on the upper side, giving rise to a single series of alternately broad and narrow figures supported on a line of sigmoids, as in Fig. 17. I would therefore claim that the upright, so-called

Fig. 17.



[1] This border is more effective when used horizontally. Vertical ornamented series are very often bilateral, and much wider than horizontal borders. Where a fret or honeysuckle border runs completely round the side of a room, we shall find that the horizontal parts give more pleasure to the eye.

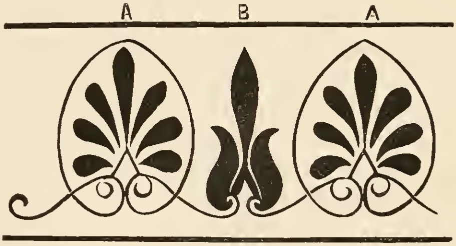
honeysuckle ornament or Anthemium was developed from the accessory ornament *A*, Fig. 15, while the oblique honeysuckle ornament, Fig. 18, appears to have been developed from the little triangles, Fig. 13.

Fig. 18.

In the Greek honeysuckle ornament the lines are not only subtile and beautiful, but they flow from one another and the parent-stems tangentially, according to a recognized and readily-explainable law in decorative art. For, just as gestures that flow tangentially from one another are more agreeable to the muscles of the arm, so lines tangential to one another are more pleasant to follow with the eye than those that start abruptly from one another.

The beautiful bounding line to the figure *A*, Fig. 19, appears to have been added after attention had been attracted to the elegant outlines of the Anthemium. When the figures *A*, *A*, were drawn close together, but little space was left for the narrow figure *B*, which was

Fig. 19.



therefore compressed as in Fig. 17. As the ornaments *A* and *B* were cultivated, the sigmoids were neglected, and, in course of time, they dropped out entirely from some of the borders, leaving, however, at the base of the ornament, two little volutes, which it is important to note are in the broad figure *A* turned in a direction opposed to that of the generating volutes. These little basal volutes are most remarkably persistent, and serve to aid us in determining the origin of many decorative forms, that have changed to such an extent, that their relation to the Anthemium would otherwise not have been suspected. Time will not allow me to trace out at greater length the line of evolution of this series of ornaments, and I can only allude to the Acanthus border as its richest and most luxuriant outgrowth. This is a matter of history, and I do not need to discuss it here.[1]

[1] The "egg and tongue" or "egg and arrow" border had originated from the honeysuckle border, in architecture, in the attempt to produce, by a narrow cornice, the gen-

Decorative art has developed through the constant attempt to please the eye by more and more beautiful forms, and in obedience to the law of *the survival of the most beautiful or of the fittest to please;* for pure, well-constructed forms are persistent, while those that are abnormal, *bizarre*, or not adapted to the eye, die out. We still, to-day, use straight lines and frets, and a multitude of beautiful forms, many of which, doubtless, have come down to us from an immense antiquity. They are normally beautiful and we shall always need them. These, I may add, are also the forms which we shall find most widely distributed.

The connection between the manufacture of pottery and the evolution of ornament is exceedingly close; and some of the most beautiful ornamental borders, etc., have originated on pottery, the soft, easily-scratched clay furnishing an excellent surface for drawing upon. In savage America the manufacture of pottery falls everywhere to the lot of women, since, as it is a branch of cooking, she, having the charge of domestic affairs, naturally makes the vessels in which to prepare food. But the Indian woman not only makes the pottery, she also ornaments it. Elsewhere, as among certain tribes in Africa, and also among the Papuans and the Feejees, woman is the ceramic artist. Llewellyn Jewett thinks that the Celtic burial-urns were made and ornamented by women. But, the world over, woman, among savage tribes, not only makes ornamented pottery, but she spins and weaves, and makes and decorates clothes. She is, in fact, the primitive decorative artist. Even in civilized life she still loves to cover with beautiful, purely æsthetic forms every thing her hand touches, and it is through her influence, more than through that of man, that decorative art flourishes to-day. I do not know whether her greater susceptibility to the influence of decorative art-forms springs from her greater delicacy of physical organization, or whether, what is perhaps more probable, it is owing to the wants of an entirely different life from that which man leads.

Ornament is something so necessary to civilized life, so universally necessary, that, like music and the other fine arts, it merits serious and intelligent study. A song is evanescent, but a good ornament "is a joy forever." To-day, in our craving, we cover every thing about us with a motley mixture of classic and detestably rude forms, and half even of the educated really do not know how to distinguish a good ornament from a bad one. Ornamental art will never take its proper rank, and be fully appreciated, until it is, in the first place, systematically studied, and, in the second place, intelligently and widely taught.

eral effect of the latter border when seen at a distance. Ruskin cannot see what arrows have to do with eggs, and, though he admits the border to be beautiful, he characterizes it as a "nonsense" ornament.

THE FUTURE OF CHEMISTRY.

By F. W. CLARKE,

PROFESSOR OF PHYSICS AND CHEMISTRY IN THE UNIVERSITY OF CINCINNATI.

EVERY science seems to have, as a science, its most rapid and brilliant growth during the earlier portions of its history. By this I do not intend to say that the mere bulk of its material increases more swiftly than at a later period, when the number of its students and investigators has become great. I mean simply that important generalizations are more readily made and more frequent, and that abstract conceptions are more speedily fertile in results. The reason for this is very obvious. At first, when any new science has but just assumed definite shape, every student has it before his mind as a unit. All parts of the field are immediately under his eye; no portion of it can easily escape notice. Thus it is studied, not less in its details, but more as a definite, consistent whole; and its growth is consistent, well-balanced, and harmonious. When, however, the field becomes larger, there is a splitting up into specialties, and, in general, each specialty is cultivated by some assiduous worker who cares but little for the character which the science may take in its entirety. In other words, the greater the mass of scientific material, the greater is the tendency among investigators to study details at the expense of generalities. Accordingly, the details multiply and become unmanageable; complexity increases, and symmetrical development comes comparatively to a stand-still.

This is emphatically true of chemistry at the present day. Only a very few chemists now study their science as a grand unit. We have technical chemists, agricultural chemists, analytical chemists, physiological chemists, and so on. Each one devotes himself to his specialty almost without reference to the others. What relation his particular branch may bear to the complete science is hardly thought of. Such questions are left to speculators and dreamers. Among those who study the abstract science, without reference to its practical applications, it is much the same. One man has all he can do to examine the derivatives of a single organic group. If he can obtain fifty new compounds in which the interlinking of the atoms may be represented in some unheard-of way, his ambition is satisfied. He chlorinates this body, and deoxidizes that; he makes numberless substitutions, all of which he knew beforehand to be possible; but what, in the end, does it amount to? In Germany, where nine-tenths of the chemists seem to be running wild over the so-called "aromatic group," this multiplication of new bodies is going on with unparalleled rapidity. And yet not one in five hundred of the substances discovered gets thoroughly described. This naphthaline derivative is a solid, with a certain odor, color, melting-point, and crystalline form; and there the description ends. No thought of ascertaining its other physical properties ever seems to enter the head of the discoverer. Doubtless all this work has a value; some of it has already led to results of great importance; still it is not in any such direction that chemistry is to look for its chief future growth. The same amount of effort, otherwise expended, would yield much richer returns. Unfortunately, an inferior line of research has become fashionable, and scientific investigators, like all other people, are more or less subject to fashion. It must be plain to every one, however, that the work of chemistry amounts to a good deal more than merely to obtain, formulate, and classify new compounds. It is necessary to study not only the bodies themselves, but also the laws involved in their formation and decay. We should seek to understand what physical forces are operative in each reaction, and in what quantities. No chemical change can occur unattended by the phenomena of either heat, light, or electricity. To-day, little is done save to investigate the *results* of chemical reactions. Surely the phenomena of the reactions themselves ought to be studied a little more. Chemistry would not lose much were no new compounds to be described for ten years to come, if chemists might only be induced to examine more closely the substances already known.

These few words of well-meant criticism may very properly lead us to the main subject of this paper: What is the future of chemistry? In what direction must the science look for its grandest development? What grand generalizations may we expect, and what steps should be taken to lead up to them? As the past is always prophetic of the future, it is evident that we must pay some attention to the former growth of chemistry before we can safely predict what is to come. If we would be thorough, we ought to do even more, and extend our view across the limits of this particular science into the fields of other sciences closely connected with it. For present purposes, however, we need consider, in conjunction with chemistry, only its twin-sister, physics. The two sciences are so closely intertwined that neither can be studied alone. Progress in either, in the long-run, means progress in both. Upon the border-land between the two our attention must be fixed.

Upon studying the history of chemistry, we cannot but be struck by the changes which have occurred both in the form and in the significance of chemical notation. There we have to deal with a symbolism so peculiar that it represents in its modern form several very important stages of scientific growth. Every great change in chemical thought is mirrored by some modification in this symbolic system. At first a formula represented the composition by weight of a substance, and embodied certain theoretical conceptions with which we have, for present purposes, nothing to do. Soon an extension of our knowledge so modified the notation of chemistry that the new formulæ, though differing but slightly from the old, represented more than composition by weight, namely, composition by volume also. Still later came the attempt, now being vigorously continued, to make every formula represent not only ultimate composition by weight and by volume, but also the probable arrangement of the atoms within the molecule. In other words, if we ignore the atomic hypothesis, a modern chemical formula aims to express some of the more important chemical relations and reactions of the body represented. In close connection with these purely chemical discoveries, we find a little physical work. Thanks to Kopp, we are able to calculate from the formula of almost any liquid its atomic volume, and thence its specific gravity at the boiling-point. Other investigators enable us to calculate the indices of refraction for different liquids, and, to a more limited extent, some other physical properties also. In short, a system of notation, originally based upon the properties of the atoms as regards weight, has been found to express also many of their other physical relations; and the list of facts thus expressed is continually lengthening. Evidently, then, the tendency of chemical investigation is to connect the physical properties of every substance directly with its composition.

Here we step over the border into physics. Plainly, if we have to deal with physical properties, we must study the forces represented by them. And, fortunately for the chemist, the tendency among physicists is entirely in his favor. Growing up contemporaneously with the development of chemical notation, we have had the grand ideas of the conservation of energy and the correlation of forces. We have learned that force is one, indestructible and uncreatable, and that all its manifestations are mutually convertible one into another. Either of the great modes of force may be active in affecting chemical composition; may cause chemical union or chemical separation; may be the motive of either analysis or synthesis. Now, in the direction here suggested, the main work of physics is being done. The chief object of the physicist to-day is to determine quantitatively the relations connecting all the different varieties of energy. Under what circumstances, and how, are forces transformed? Since these transformations are differently effected through the intervention of different forms of matter, it is clear that the physicist must take into account the chemical composition of the materials with which he deals. In short, then, the chemist must look to physics for a knowledge of the forces involved in chemical changes; while, on the other hand, the science of physics must needs throw from chemistry its information upon the nature of all the material agencies through which the transformations of force become apparent. Neither physics nor chemistry can work independently of the other; the more closely they become allied in the labor of investigation, the more rapidly will both progress. The two lines of research converge more and more day by day; in the end they will unite and become one.

To sum up our reasonable expectations, we may hope that before long the chemist, from the composition of any substance, will be able to calculate all of its physical properties — boiling-point, melting-point, specific heat at every temperature, expansibility, density, index of refraction, conductivity for heat and for electricity, and so on to the end. I, for one, do not doubt that the day when this will be possible is approaching more rapidly than the majority of chemists suppose. Until that time arrives chemistry cannot claim the honor of being an exact science. In physics a result is to be accomplished which will be complementary to this. Given the quantitative relations of the forces, we ought to be able, from the properties of any body as regards one force, to compute its properties with regard to all others. Knowing the thermal relations of any substance, for example, we shall eventually be able to calculate at once its optical, electrical, and magnetic properties. These results, to be achieved by physics, can be brought about only in connection with the chemical investigations which this paper is intended to emphasize.

But the future of chemistry does not end with the completion of the researches which we have thus far considered. It is the glory of science that every great achievement only opens the way for still greater achievements lying far beyond. So, when chemistry shall have reached the splendid future which I have ventured to suggest, it will only find itself possessed of materials with which to start for a grander future far away in the dim distance. We may expect that an exact knowledge of the laws governing the physical properties of substances will enable us to foresee just what compounds are possible, and by what reactions they may be obtained. Throughout the science, accurate calculation will be substituted for much abortive experiment, and both time and labor will be saved. The same lines of investigation, prolonged still further, will settle the much-vexed question of the nature of the elements; so that we may hope to know whether they are all but varieties of one or two, or whether they are many and essentially dissimilar. Upon the same experimental basis the truth or falsity of the great atomic theory may rest. Given the knowledge which we may expect to have concerning the physical relations of substance, and we ought to be able to devise many crucial tests for the idea of the atomic constitution of matter. All the great speculative questions of modern chemistry must be eventually fought out upon the battle-field of physics.

Now, having recognized some facts concerning the intellectual future of chemistry, let us inquire what material steps will best lead up to them. What experimental work is most needed to begin with? Plainly, if we are to discover laws connecting the physical properties of compounds with their composition, we must first determine the physical properties of the elements. This work should be done with the greatest care and thoroughness. Every element should have its relations to the forces of Nature thoroughly fixed and tabulated. Even the rarest elements ought not to be neglected, since each one has its scientific importance, fills a place in some series or groups, and, for purposes of generalization, is of as great interest as any other. But, as it is to-day, the commonest substances have been very imperfectly studied. Only a few constants have been determined for some of the most familiar elements, the gases especially. Just enough is known about the commoner metals to show us how ignorant we really are. Here, then, is a great field for work, and in it some of the richest materials for both chemistry and physics are to be gathered. It is, indeed, strange that this work, obviously of such vast importance, should have been so long postponed. Of course no single individual could undertake it, but it seems as if some learned society, or even some government, might assume the burden. A twentieth part of the money expended for the determination of one astronomical constant, the earth's distance from the sun, ought to cover all the expenses of the undertaking. If we had in America a laboratory exclusively devoted to research, suitably manned and equipped, our country might carry off the glory of achieving this grand work. In default of such a laboratory, however, the labor might be accomplished through the coöperation of many individual workers, each one doing his small part, not aimlessly, but in unison with the others. One chemist might undertake to furnish certain of the elements in a perfectly pure condition; another might carefully determine under varying circumstances their densities and rates of expansion; a third could work up their specific and latent heats; a fourth their electrical relations, and so on. Failure to attain grand results would be impossible. Doubtless the labor would prove irksome and monotonous, but the reward would be sure. In five years, more would be done toward rendering chemistry an exact science, than can be accomplished in a century by means of the chemical investigations at present most in vogue.

The physical properties of the elements being established, the next thing is to do somewhat similar work for compounds. And here, before entering on experimental labors, it is necessary to know what has already been done. This knowledge is at present difficult to obtain, since the materials are scattered through many pages of many volumes of scientific transactions and periodicals, and need to be collected and systematically arranged. This work of tabulation having been finished, chemists will be able to see distinctly where experiment is most needed, what must be done entirely new, and what ought to be done over again. Then, some of the experimental details might be easily intrusted by professors to the hands of students. If, for practice, a student is taking specific gravities, let him work upon substances for which that constant has never been determined. So also with such other physical measurements as naturally come up in a college laboratory. The student would be getting his instruction at the same time that he felt himself interested in aiding science, and both he and science would be gainers. The material so collected might hardly be of the highest accuracy, but it would certainly not be quite without scientific value. Any one, who will examine the nature of the material already on hand, will forcibly realize this fact.

It would be easy to multiply suggestions. Any chemist, who will carefully survey the field, will be surprised at the immense amount of obviously important work which has hitherto been left undone, and which should take precedence of nearly all the chemical investigations now most in fashion. The necessity of this work is based upon no wild speculations, but upon a foundation of the most severely practical ideas. No extraordinary difficulties hedge it about, no real impracticabilities stand in the way. Certain great laws ought to be discovered, and they can be discovered only by means of researches such as are here suggested. A few years of steady, earnest work upon the part of fifty scientific chemists would accomplish all the chief results which I have ventured to prophesy.

CONCERNING BEARS.

By WILLIAM E. SIMMONS, Jr.

THE bear family (*Ursidæ*), though comprising a comparatively small number of species, is yet one of the most wide-spread of all the carnivora, being found all over the earth's surface, except in Africa and Australia. In the latter country, there is an animal somewhat resembling the bear in appearance, and having the tree-climbing habit, known popularly as the Australian bear. This animal is, however, not a bear, but belongs, with its cousins, the kangaroo, bandicoot, and opossum, to another family. Regarding the existence of the bear in Africa, there has long been some difference of opinion. Herodotus, Virgil, and other ancient writers, speak of Libyan bears. Pliny alludes to Numidian bears being exhibited by Ethiopian hunters in a Roman circus, 61 B. C. Latterly, Ehrenberg and Forskal both mention a black plantigrade animal, called by the natives *karvai*, which inhabits the mountains of Abyssinia. They hunted and saw it, but failed to capture a specimen. It is possible that the bear may yet be found in at least a portion of the vast unexplored area of that continent, but the opinion that it does not exist there is now generally held by naturalists, and it may reasonably be entertained, until controverted by the finding of a specimen.

The general characteristics of the bear are the rough, shaggy coat conspicuous massiveness of the hinder parts, which gives a peculiar shape to the body; plantigrade gait, and the habit of erecting the body and standing upon the hind-feet when attacked or in combat. The feet, especially the paws, are armed with long, sharp claws, not retractile, nor so much crooked as are those of the feline tribe, nevertheless capable of inflicting terrible wounds when impelled by the powerful force which the bear can exert. The bear is both carnivorous and vegetarian, and will apparently thrive on either a purely animal or vegetable diet. It is a gregarious animal, extremely sociable, subject to strong attachments for its mate and young, and, in a state of domestication, for man. Most of the species are good climbers, and all are good swimmers. Excepting a few species, it is a singularly harmless animal while undisturbed, but is ferocious and dangerous when attacked, or when defending its young. Its sagacity, strength, and surprising tenacity of life, render it a formidable combatant. It is remarkably adroit in guarding itself against the blows of an antagonist, and will ward off even the heaviest with wonderful dexterity. In combat, it rears upon the hind-feet and strikes powerfully with its paws; it also endeavers to crush the body of its antagonist by hugging, and will at the same time inflict fearful wounds with the claws of its hind-feet. Although so ferocious when aroused to anger, it is (excepting the polar and the grizzly) easily domesticated, and makes a most affectionate and amusing pet. One of the most curious characteristics of the bear is its habit of hibernating through the winter. During the autumn it becomes very fat, and, about the end of October, completing its winter house, ceases feeding for the year. A remarkable phenomenon then takes place in the animal's digestive organs. The stomach, no longer supplied with food, contracts into a very small space. A mechanical obstruction called the "tappen," composed of fine leaves, or other extraneous substances, blocks the alimentary canal, and prevents the outward passage of any matter. The bear continues in its den until the middle of April, in a dull, lethargic condition. If discovered and killed at any time in this period, it is found to be as fat as at the beginning. It is said, however, that, if it loses the "tappen" before the end of its hibernation, it immediately becomes extremely thin. During the hibernation the bear gains a new skin upon the balls of its feet, and, during the same time also, the female brings forth her young, from two to four in number. The latter act occurs generally from the middle of January to the middle of February. The pairing season occurs in the summer, from June to September. The period of gestation is about seven months, and the newly-born cubs are scarcely larger than puppies.

The visitor to Central Park, who walks along the corridor east of the Museum building, cannot fail to be struck with the grizzly bear (*Ursus horribilis*, or *U. ferox*). His mixed brownish and steely-gray coat, great size, massive proportions, and, above all, his ferocious aspect, render him one of the most conspicuous objects there. Observe his great broad head, with the small, cruel, brown eye, pointed muzzle, and powerful jaws, which, opening occasionally, display a set of alarming teeth. His fore-limbs, by their size indicating enormous strength, are each armed with five claws from four to five inches long, nearly straight. These claws are not needle-pointed like the cat's, but come to an edge like a chisel, and they are extremely sharp. His hind-limbs

FIG. 1.—GRIZZLY BEAR (*Ursus horribilis*).

are even more massive still, and are also armed with similar though shorter and more curved claws. His tail is so short that it is hidden by his coat. All this time he has been contemptuously eying us from the back part of his cage, but now he has become impatient of our scrutiny, and suddenly reaches toward us with open mouth, uttering a savage sound between a sigh and a growl. He then turns to gallop around his cage, and affords an opportunity to observe one of his most striking peculiarities. This is his curious, shambling gait. His fore-limbs go in a canter, while his head sways from side to side, and the rest of his body slides along upon the soles of his hind-feet. Mr. Darwin would be sure to call this sliding movement an inherited peculiarity, acquired by the grizzly's ancestors in sliding down the glaciated sides of the Rocky Mountains. He has it, whatever may have been the manner of its coming to him, and constant practice of it has worn the floor of his cage white and smooth. The grizzly is the largest member of his family; a full-grown male being from eight and a half to nine feet long, and the girth of the body is equal to the length. The average weight is about 800 pounds. The one we have been regarding is a fine specimen, being between seven and eight feet long. The color is not uniform, being in some cases of a dull brown, in others almost black, and in still others almost white. The head is covered with short, brown hair; the ears are short, and the depression between the brow and the muzzle considerable. The head is much larger in proportion to the size of the body than in other bears; and its feet, also, with the single exception of the polar bear, in which there obtains a still larger proportion. His haunts are the Rocky Mountains and the plains eastward; he is also commonly found westward, and as far north as latitude 61°. His principal food is flesh; but fruits and other vegetable substances also form a part of his diet. The younger animals are tree-climbing, but the older are not, seemingly, from their great weight. The pregnant female and the young animals hibernate, but the full-grown males are as active in winter as at other seasons.

The grizzly is the most ferocious and terrible of all American animals. He exercises absolute terrorism over every living creature that comes in his way. It is said that even the hungry wolf will flee at the sight of his track, and no animal will venture to touch a deer that has been killed and left by him. His strength is such that, even the powerful bison falls an easy prey, and a single blow from one of his paws has been known to remove the entire scalp from a man's head. He is the only member of his family that will venture to attack man unchallenged, but it is said that he will retreat at the scent of a man, if he can do so unobserved. He has attributed to him a peculiar habit, of digging a pit for his fallen prey, in which he covers it over

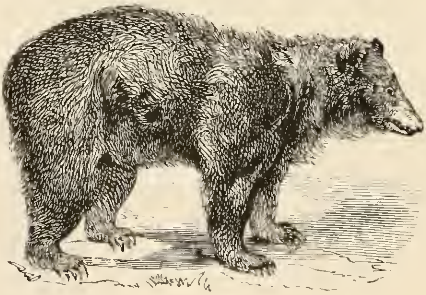


Fig. 2.—Black Bear (*Ursus Americanus*).

with leaves and rubbish. Hunters, knowing this habit, have saved their lives in desperate cases by feigning death without wounding the bear, escape being made while the latter is continuing his ramble in search of other prey. He is so tenacious of life that, unless shot through the heart or brain, his body may be riddled with bullets without fatal effect. One which had received two bullets through his heart, besides eight in other parts of his body, survived more than twenty minutes, and swam half a mile. The grizzly is not easily tamed unless captured at a very tender age, but even then he is rough in habits and dangerous as a pet.

Next to the grizzly's cage is that of the black bear (*Ursus Americanus*). It contains several animals of both sexes. One of the males is a very fine specimen, being about the maximum size of his species, five and six feet in length. His coat is a glossy black, the hairs being much shorter than those of his neighbor. On his cheek the hair assumes a brownish hue. His head is much smaller in proportion to his body than is the grizzly's, it is also narrower, and shows a more decided convexity of facial outline. The muzzle is longer and narrower in proportion to the size of the head. The limbs are far less massive and proportionally longer, the feet smaller, and the claws decidedly shorter and more crooked. His eyes, too, are larger, and he has, instead of the savage, rather a mild and good-humored aspect. In keeping with his appearance, he displays a decided disposition to be sociable, and readily puts his nose through the bars to receive fragments of cake or other delicacies that are offered him by the children. Vegetable substances constitute his principal food, although he is occasionally driven by hunger to steal a pig. Sometimes he has been known to attack and kill even a cow. He is a noted depredator on maize and melon fields; honey is his delight. He is a great climber,

FIG. 3.—CINNAMON BEAR (*Ursus occidentalis*).

and an assiduous searcher for "bee-trees," which he no sooner finds than climbs, proceeding to gnaw through the trunk to the nest of the bees. As soon as an aperture large enough to admit his paw has been made, honey, comb, and bees are scraped with avidity into his capacious mouth.

The black bear is common all over the eastern division of the United States, from Maine to Florida, and in fact over a large part of the Western territory. In the colder parts of this area it hibernates, but the habit does not seem to be general, at least with the males in the warmer parts. It is said that even in the cold latitudes it will not hibernate, unless it is fat at the beginning of the winter. The young, varying from one to four in number, are brought forth during hibernation in January or February. At first they are not more than six to eight inches long, and are covered with gray hair. They retain this color until the second year, when it gives place to black. The yellow Carolina bear is merely the young black bear assuming its distinctive color.

The black bear is much hunted for its skin, and the fat which constitutes the esteemed bear's-grease of commerce. Its numbers have been greatly diminished from this fact. Its flesh forms a good article of food, resembling pork, but with a peculiar flavor. Although easily tamed and naturally docile, it is a dangerous combatant when pursued and roused. The cinnamon bear (*Ursus occidentalis*) is a variety of the black bear, differing in color, as indicated by its name. It is found in California, and generally west of the Rocky Mountains.

FIG. 4.—MALAYAN SUN-BEAR (*Helarctos Malayanus*).

In the building to the west of the Museum we find a small female specimen of the Malayan sun-bear (*Helarctos Malayanus*). It no sooner observes us pause, than it rears up and extends its paw through the bars in a singularly imploring manner to induce us to give it some food. This, however, we are politely warned against doing by the following notice, "*Please don't feed the animals!*" which is placed against the cage. The Malayan bear is one of the smallest of the *Ursidæ* family, being at its greatest development only about four feet six inches long. Its color is deep black, with a yellowish muzzle and a white spot on the breast in the shape of a crescent with the horns turned up. The neck is shorter and thicker than in other species. Its diet is chiefly vegetable, the cocoa-nut being its favorite food. It is very destructive to the cocoa-nut groves, from its habit of devouring the succulent shoots that crown the tree. It is easily tamed, and becomes extremely docile and amusing. The name sun-bear (*Helarctos*) has been applied to the animal to indicate its habit of basking in the sun.

The spectacled bear (*Ursus ornatus*), inhabiting the Cordilleras of South America, displays all the distinctive features of the Malayan spe-

FIG. 5.—THE SPECTACLED BEAR (*Ursus ornatus*).

cies except the semicircular white patches over the eyes which give it its name. The two are evidently varieties of the same species.

The brown bear (*Ursus arctos*) is the most widely distributed of all the species. It is found throughout Europe and Northern Asia, from Scandinavia to the Himalayas. In size it is superior to the black bear of America, but inferior to the polar bear. The length is generally from about five feet, and the weight five to six hundred pounds, although it sometimes attains to seven or eight hundred pounds. The color is brown, slightly variable in tint with different individuals, and with the same individual at different ages. The neck of the younger animal is in some cases encircled by a white collar, which disappears as age increases. The prominence of the brow is much more marked than in other species, the soles longer, the claws smaller. It hibernates during the winter in caves and hollow trees, and, where these are not to be found, in holes dug into the earth and covered with moss. From one to four cubs are produced at a time. The principal food of the brown bear is vegetable substances, honey, and the larvæ of the ant. Like the black bear, it is an excellent climber, and wages relentless warfare against the bees. The taste for animal food seems to be not altogether natural, but when once acquired is never lost. An individual having tasted blood will continue to depredate on the neighboring folds until he falls a victim to the indignation of the farmer.

It will occasionally attack man, especially in the colder parts of its range, and is always dangerous and ferocious in combat. The Scandinavians say in regard to this bear that it "has the strength of ten men and the sense of twelve." They also have a superstitious reverence for it, and habitually avoid saying "the bear" by using such appellations as the "*old man with the fur cloak*," the "*disturber*," the "*dog of God*," etc. The Indians of America have a similar reverence for the black bear. The killing of one is always followed by a religious ceremony designed to conciliate the manes of the dead animal. The head is decorated with trinkets and placed upon a blanket, where the successful hunter blows tobacco-smoke into the nostrils, and

FIG. 6.—THE BROWN BEAR (*Ursus arctos*).

makes a conciliatory speech, regretting the necessity for the killing. As an instance of the cunning of the brown bear, it is related that, when he is desirous of attacking man, the circle of fire, which proves such an effectual safeguard against other animals, is of no avail against him. He will not attempt to walk through the flames, but retiring, immersing himself in the nearest stream, will return and roll his body over the brands until the flames are smothered, when he will attack the sleeper. Yet for all this he is, when in good condition, a gentle and humorous fellow. Two children of a Siberian farmer, aged four and six respectively, one day wandered away from home. The parents, in searching for their children, were amazed to discover them at play with a large bear. One of the children was mounted upon the bear's back, while the other was feeding him with berries. The terrified parents began to scream, whereupon the bear quietly left the children and went into the wood. The brown bear is spread over Asia, from the Himalayas northward, but in different localities it undergoes slight modifications of color, and has therefore received different names; hence the Siberian bear (*Ursus collaris*), and the Syrian bear (*U. Isabellinus*). The former is said to have a white collar around the neck,

FIG. 7.—SYRIAN BEAR (*Ursus Isabellinus*).

which is probably the distinctive mark of the younger bear. In the latter, the brown color changes into a yellowish hue, from which the term Isabel bear is derived. The brown bear of the Himalayas is of the same species. It seems likely also that it inhabits the extreme northwestern part of North America. Sir John Richardson relates having found in the barren lands lying to the northward and eastward of the Great Slave Lake, extending to the Arctic Sea, a bear which agrees with this in many respects. Still, nothing definite is known to establish the identity of the two.

One of the most curious members of the bear family is the Asiatic or sloth bear (*Ursus labiatus*). It is distinguished from other bears by the length of its hair, the length and flexibility of its lips, and the peculiar manner in which the fore-feet cross each other in walking. Its fur is deep-black, slightly flecked with brown, but it has a forked patch of white upon the breast. The hair from the head and neck hangs down over the face, and gives the animal a weird appearance. It seems to be subject to the early loss of its incisor teeth, from the absence of which, in the first specimens carried to England, it was supposed to be a species of gigantic sloth. It is almost wholly a vegetable feeder, and, it is said, will resort to animal food only in cases of extreme hunger. It is quite harmless unless retreat is cut off, when, like its relatives, it becomes savage and dangerous. The mother will fight bravely in defense of her young, which she usually carries upon her back until they have acquired strength enough to make good travelers. It is an inhabitant of the Himalayas, where it remains in caves during the day, and performs its rambles by night. This habit is attributed to the fact that the soles of its feet are covered by a skin so tender as to be easily blistered by the sun-heated rocks which constitute the surface of its mountain-home.

In the polar bear (*Ursus maritimus*) the bear family possesses an aquatic member. It is inferior in size only to the grizzly bear, and is scarcely second to him in strength and ferocity. Its color is silvery white, tinged with a slightly yellowish hue, which varies in intensity with different individuals. The neck is longer in proportion to the

Fig. 8.—Asiatic or Sloth Bear (*Ursus labiatus*).

body than in any other bear, and the head is far smaller, and very much pointed. It is also characterized by almost entire absence of facial angle, there being a nearly unbroken line of descent from the forehead to the nose. The foot, also, is of greater comparative length, being about one-sixth the length of the body, while in the brown bear it is only one-tenth. The sole is covered with a thick fur, which enables the animal to tread firmly upon the ice. The claws are slightly curved, though not very long. They are quite black, so that they stand out in strong contrast with the fur surrounding them.

The polar bear is necessarily carnivorous, from the circumstances under which it exists, vegetable food being absent from its icy haunts; however, when captured and brought to warmer latitudes, it will subsist on a vegetable diet. It lives on fish and seals, and is said to occasionally capture a walrus. Its movements are remarkably quick. One was observed to dive from a block of ice and capture a passing salmon. Its mode of capturing the seal evidences much sagacity. Observing the position of the basking seal, it dives into the water and swims in that direction beneath the surface, occasionally sticking out its nose to "catch a breath." Proceeding thus, it rises at length close to the seal, which, cut off from the water, falls an easy prey, escape over the ice being impossible, on account of the swifter movements of the bear.

This bear seldom attacks man if unmolested. The pregnant females hibernate, but the males and other females do not. The first scrapes a hole into the snow, where, buried as it were, she passes the winter, bringing forth her babies, generally two in number, during that time. The mother will always die before leaving her cubs in danger, and, if they be killed first, she is said to make a most affecting display of grief. The flesh of the polar bear is highly esteemed by the arctic voyagers as an article of food.

FIG. 9.—POLAR OR WHITE BEAR (*Ursus maritimus*)

Scattered throughout Europe are the remains of extinct bears, usually found in caves, from which fact they are said to belong to the cave-bear. They have been divided into two species, *Ursus spelæus* and *Ursus priscus*. The former is larger than any living species. In a recent number of the *Popular Science Review*, Mr. A. Leith Adams, M. B., F. R. S., makes an interesting attempt to establish the identity of the grizzly and the *Ursus spelæus*. He thinks that the former was at one time common to Europe, and that the latter were only larger individuals of the same species. He was led to this conclusion from observations on the brown bear of the Himalayas, in which species he found that certain males occasionally grow much larger than the average, and that such are peculiarly addicted to living in caves, from which they seldom wander except for a few hours daily. It seems, also, that certain slight modifications of the skeleton occur in the overgrown individuals. Reasoning from analogy, he concludes that, when means of subsistence were abundant in Europe, it is likely that a similar peculiarity of excessive growth in certain individuals also characterized the grizzly species. This hypothesis, he thinks, sufficiently accounts for the difference in size, while the cave-loving habits of the larger individuals would explain the preservation of their remains. The *Ursus priscus* he regards as identical with the brown bear (*Ursus arctos*).

Regarding the distribution of bears, we have found the grizzly restricted to the Rocky Mountains and the adjacent plains; while the black bear takes his place in other parts of the North American Continent, except in the extreme northwest. The Malayan bear we found distributed over the archipelago that bears its name, the southern part of Asia, and even South America, though with slight modifications. The brown bear (*Ursus arctos*), we have seen, holds undisputed sway of Europe, of Asia north of the Himalayas, and that it probably extends even to the northwestern part of North America. And, in marked contrast with this wide range, we find the sloth-bear confined to the Himalayas, and the polar bear to the Arctic Ocean.

WOMAN'S PLACE IN NATURE.

By FRANCES EMILY WHITE, M. D.

PROGRESS in knowledge is defined by Herbert Spencer as "the bringing of thoughts into harmony with things." Plato enunciated the same great truth more than two thousand years ago. "Man," he says, "is not a system-builder; his loftiest attainment reaches no higher than this: through endeavor, through discipline, through virtue, he may *see* what *is*." Recognizing the profound wisdom of these utterances of the ancient and the modern master, I propose, in studying the nature and place of woman, to be guided by this principle, which has led to results so satisfactory in other departments of science, and, forgetting theories, to study woman as she is. Should some onward glances be attempted, "a scientific use of the imagination" only will be indulged in, and the possibilities of the future will be inferred from the actualities of the past and the present.

As man's place in Nature is to be comprehended only by comparison with the various grades of organisms below him in the scale of being, so woman's place, as compared with that of man, is to be rightly understood only by a study of the relations of the sexes through the whole range of organized beings, involving a consideration of vegetable existence even, since sex accompanies all its higher forms. Paradoxical as it may seem, the less includes the greater—evolution being an unrolling or unfolding of that which potentially exists. It is by means of such a review, if at all, that we may hope to find answer to the questions of the day, relating to woman. How does she differ from man, and to what extent do these differences modify or determine her place in life? In other words, how does that differentiation of the human germ which we designate as feminine, influence the organism as a whole? Will these questions admit of complete solution? Probably not; no great question has ever yet been fully answered—and, although the human organism may be divided, for purposes of study, into numerous sets of apparatus, each having a definite office in the general economy—as the digestive apparatus, the reproductive, the intellectual, etc.—the correlation of all the forces and functions of the body is so intimate and subtile that true philosophy makes no attempt to measure the exact and separate influence of any one force or function upon the rest, or upon the organism as a whole. Hence, to estimate the influence of sex in any given organism is impossible upon general principles, and evidently so in the case under consideration, from the fact that there is no standard of comparison. To assume man as the standard would be obviously absurd, for he is as distinctively differentiated as is woman, and it is impossible for a scientific imagination to conceive of a common type of the human species excluding the idea of sex; the attempt would demonstrate the impossibility of separating the mental conception of its two phases—just as it would be impossible to conceive of a magnetic needle without polarity. Its opposite poles may be designated and described, their peculiarities discussed, and their superficial relations partially understood; but who has any distinct idea of the real significance of their relations? The only clear thought is that they are complemental, and incapable of separate existence—furnishing a complete example of perfect duality in perfect unity; and the absurdity of the idea of a "common type" of its two poles is obvious. If any thing, it would be a magnetic needle without magnetism; in other words, a conceived inconceivability! Recognizing the difficulties which beset this investigation, then, the most that can be hoped for is the attainment of some broader and deeper truth than appears on the surface of the present disturbances in the social world; the only legitimate inquiry seems to be in regard to the influences and conditions which have resulted in the woman of to-day; and the practical questions related to it: Is there a tendency toward any important change in these influences and conditions, and, if so, in what direction? From what has gone before, my readers will have already inferred that the study of this subject will unavoidably include that of its natural complement, and that, should we succeed in obtaining answer to these questions, others of equal interest will find solution.

While the distinction of sex has for its manifest object the continuation of the race, that it is of deeper significance than this—that it has important bearings upon race-development as well as race-preservation—is indicated by a mass of evidence of so great weight as to carry with it the force of a demonstration. In Darwin's "Descent of Man" we have an accumulation of statements of facts gathered from vast fields of observation by many of the foremost naturalists of the age; and his deductive interpretations of these facts seem to have been accepted by a majority of the leading naturalists and physicists of the day. Such being the case, we are warranted in making this work the basis of our inquiry, thus looking at the subject from the side of natural history. Should some additional deductions and interpretations be brought out, it is hoped that they will not be found either forced or imaginary.

In order to a clear understanding of the line of reasoning employed, we must distinguish between the terms "natural selection" and "sexual selection," as used by Darwin. The traits resulting from these two processes are under a different law of heredity—those arising through natural selection being transmitted alike to the young of both sexes, while the results of sexual selection are inherited mainly by the adults of the corresponding sex. It will be seen that these are important laws, and that they furnish a key to our inquiry into the conditions and influences which have resulted in the woman of to-day. Under the operation of this second law (quoting from the "Descent of Man"), "it is the male which, with rare exceptions, has been chiefly modified—the female remaining more like the young of her own species, and more like the other members of the same group. The cause of this seems to lie in the males of almost all animals having stronger passions than the females. Hence it is that the males fight together, and sedulously display their charms before the females; and those which are victorious transmit their superiority to their male offspring." The question naturally arises, How have the males of the lower animals acquired this greater strength of passion? Says Darwin: "It would be no advantage, and some loss of power, if both sexes were mutually to search for each other; but why should the male almost always be the seeker?" Reasoning from the lower forms of life, he points out the fact that the ovules, developed in the female organs of plants, must be nourished for a time after fertilization; hence the pollen is necessarily brought to them—being conveyed to the stigma by insects, by winds, or by the spontaneous movements of the stamens themselves, upon which the pollen grows. "With lowly-organized animals permanently affixed to the same spot, and having their sexes separate, the male element is invariably brought to the female; and we can see the reason; for the ova, even if detached before being fertilized, and not requiring subsequent nourishment or protection, would be, from their larger relative size, less easily transported than the male element. . . . In case of animals having little power of locomotion, the fertilizing element must be trusted to the risk of at least a short transit through the waters of the sea. It, would, therefore be a great advantage to such animals, as their organization became perfected, if the males, when ready to emit the fertilizing element, were to acquire the habit of approaching the female. The males of various lowly-organized animals having thus aboriginally acquired the habit of seeking the females, the same habit would naturally be transmitted to their more highly-developed male descendants; and, in order that they should become efficient seekers, they would have to be endowed with strong passions. The acquirement of such passions would naturally follow from the more eager males leaving a larger number of offspring than the less eager."

I have quoted thus at length upon this point, in accordance with the principle already laid down, that the lower is a type of the higher.

Following Darwin's argument—"the greater eagerness of the male has thus indirectly led to the more frequent development of secondary sexual characters in the male than in the female"—secondary sexual characters being those not directly concerned in reproduction. Among these are the greater size, strength, courage, and pugnacity of the male, which most naturalists admit to have been acquired or modified by sexual selection—not depending on any superiority in the general struggle for life, but on certain individuals of one sex, generally the male, having been successful in conquering other males, and thus having left a larger number of offspring to inherit their superiority.

In the human species, the differences between the sexes are marked. The greater size and strength of man are apparent. His broader shoulders, more powerful muscles, greater physical courage and pugnacity, may be plainly claimed, by Darwin and his adherents, as man's inheritance from a long line of ancestry, of which the vanishing-point is in the remote past, among the lowest forms of life.

Whether or not this relationship be accepted, the same principles which have prevailed among lower animals must have been operative in the progress and development of the human race.

During the long ages when man was in a condition of barbarism, it must have been the strongest and boldest hunters and warriors who would succeed best in the struggle for existence, thus improving the race through the operation of natural selection, and the survival of the fittest; while the stronger passions accompanying these traits would lead to their success in securing the wives of their choice.

They would necessarily, by means of the same advantages, leave a more numerous progeny than their less successful rivals. It is here that the laws of sexual selection and heredity come in to maintain and increase the differences between the sexes. Who can doubt that a difference in mental characteristics would result from such causes? The greater necessity for exertion on the part of men would inevitably result in the development of more robust intellects. "Mere bodily size and strength would do little for victory unless associated with courage, perseverance, and determined energy.

"To avoid enemies or to attack them successfully, to capture wild animals, and to invent and fashion weapons, require the aid of the higher mental faculties, namely: observation, reason, invention, or imagination. These various faculties will thus have been continually put to the test and selected during manhood; they will, moreover, have been strengthened by use during this same period of life.

"Consequently, in accordance with the principle often alluded to, we might expect that they would at least tend to be transmitted chiefly to the male offspring at the corresponding period of manhood. . . . These faculties will have been developed in man partly through sexual selection, that is, through the contests of rival males, and partly through natural selection, that is, from success in the general struggle for life. . . .

"Thus," continues Darwin, "man has ultimately become superior to woman." We will say, rather, thus have men and women come to differ mentally as well as physically. We will take further testimony, and inquire what sexual selection has been accomplishing for women during these long periods of man's physical and mental development, before accepting the unmodified dictum of superiority.

The authority so frequently quoted tells us that "the equal transmission of characters to both sexes is the commonest form of inheritance," and that "this form has commonly prevailed throughout the whole class of mammals." Hence the advantages primarily gained by man have been bestowed upon his descendants of both sexes, though, as has been shown, in a somewhat less degree upon the female. Let us now glance at the converse of these vivid pictures of the advantages accruing to man through habits and conditions arising from primary sexual characters, and endeavor to learn whether the habits and conditions necessarily attaching to the female have been the source of any gain either to herself or to the race as a whole.

The less degree of hardship and exposure to which she has been subjected have doubtless tended to develop in her the physical beauty in which she is generally acknowledged to be man's superior; while the fact that women have long been selected and prized for their beauty will have tended, on the principle of sexual selection, to increase the differences originally acquired through natural selection.

The "sweet low voice" which has so long been accounted "an excellent thing in woman," has undoubtedly been gained in a similar manner. In the pursuit of her more quiet avocations there would be less likelihood of the development of large and powerful vocal organs, as it is during the excitements of battle and the chase that the fiercest yells and wildest shouts are produced. The perception of musical cadences, and a sensitiveness to the influence of rhythm, manifested even by many of the lower animals, naturally associating themselves with the rhythm of motion, would tend to early development, on the part of the female, in the care and nursing of her young; while sexual selection has probably played a still more important part in the origin of music.

"Although," says Darwin, "the sounds emitted by animals of all kinds serve many purposes, a strong case can be made out that the vocal organs were primarily used and perfected in relation to the propagation of the species."

Many of the lower animals are mute except during the breeding-season, and the calls, melodious or frightful, of most animals have either a social, an amatory, or a maternal meaning. Thus, through the principle of inherited associations, music asserts its sway over the deepest emotions of the nature — spoken of by Herbert Spencer as arousing "dormant sentiments of which we had not conceived the possibility, and do not know the meaning," and apostrophized as follows by the more impassioned Richter: "Away! thou tellest me of that which I have not and never can have; which I forever seek, and never find!" Its mysterious influence is explained by Darwin as consisting in its power of exciting sensations and ideas which "appear from their vagueness, yet depth, like mental reversions to the emotions and thoughts of a long-past age."

Woman, unable to obtain an influence by those means so readily at the command of man, will have naturally resorted to milder measures, both for securing any desired object, and in self-defense; and music, appealing as it does to the gentler and more tender emotions, will have been often employed in arousing the better nature of him at whose mercy her inferior strength has placed her. Thus she will have held the ruder passions of man in check, and, in taming his wilder nature, will have developed an increasing gentleness both of feelings and of manners in the entire race.

During the battles of rival males, the female will have occupied the less active but more dignified position of arbiter and judge. Not being in the heat of the conflict, she will have had opportunity to observe the strategy of each, and to weigh their comparative merits. By this exercise of the faculties of observation, comparison, judgment, and reason, her intellectual powers will have been "continually put to the test and selected during" womanhood. Unfairness in the conduct of the battle will doubtless have roused her indignation, and compelled her better feelings in favor of the more honorable combatant. Sympathy for the vanquished will sometimes have taken the place of exultation in the superior prowess of the victor, and admiration for mere muscular power will have had to contend with these finer emotions.

While man has been engaged in contests with the common enemy, during which his fiercest passions will have been aroused, woman has been subjected to the discipline of family life. To meet emergencies successfully, to provide for the sick, to maintain order and discipline in the household, which, at an early period in human history, included slaves as well as children, will have required mental powers of a high order. At the same time she will have developed a milder character through the exercise of the beneficent traits of maternal love, and solicitude for the absent husband and father. These feelings of tenderness and love will have gradually prepared the way for the development of the devotional sentiment, and will have thus furnished a basis for the deeper religious nature which has become a part of woman's birthright.

Darwin says that the foundation of the moral qualities lies in the social instincts, including in this term the family ties—the more important elements being love and sympathy.

Thus it appears that while sexual selection and intellectual development have gone hand-in-hand, it is no less true that the moral and emotional sides of human nature have been developed by the operation of the same laws mainly through the female portion of the race. Though Darwin scarcely does more than touch upon this phase of the subject, he says: "Woman seems to differ from man in mental disposition, chiefly in her greater tenderness and less selfishness;" and again: "It is indeed fortunate that the law of equal transmission of characters to both sexes has commonly prevailed throughout the whole class of mammals; otherwise it is probable that man would have become as superior in mental endowments to woman as the peacock is in ornamental plumage to the peahen."

I shall refrain from indulging in any "would-have-beens" upon the moral aspects of this picture, in the contingency to which Darwin alludes, since we are concerned only with what *is*.

Our authority continues; "That there is a tendency to the equalizing of the sexes is undoubted in many of the secondary sexual characteristics; woman bestows these superior qualities on her offspring of both sexes."

Applying the principles, to the operation of which he imputes man's mental superiority, we will add—though in a greater degree upon her adult female offspring, since it is during her maturity that these qualities of greater tenderness and less selfishness are most called into exercise.

Although Darwin states that man has been more modified than woman by the law of heredity in connection with sexual selection, he admits its force in the development of both sexes by many statements which might be quoted, were it necessary. The principal argument against its eqnal force in the two cases is found in the fact that the young of both sexes in many animals, including the human, most resemble the mother. While this is true in a limited sense, the points of greater resemblance being mainly of a physical character, as superior softness and smoothness of skin, greater delicacy of muscles, muscular tissue, etc., it is not applicable to the qualities of tenderness and unselfishness, the cruelty and selfishness of children, especially boys, being proverbial.

Still quoting from the same work: "Although men do not now fight for the sake of obtaining wives, and this form of selection has passed away, yet they generally have to undergo, during manhood, a severe struggle in order to maintain themselves and their families, and this will tend to keep up, or even increase, their mental powers, and, as a consequence, the present inequality between the sexes. . . . In order that woman should reach the same standard as man, she ought, when nearly adult, to be trained to energy and perseverance, and to have her reason and imagination exercised to the highest point; and then she would probably transmit these qualities chiefly to her adult daughters. The whole body of women, however, could not be thus raised, unless, during many generations, the women who excelled in the above robust virtues were married, and produced offspring in larger numbers than other women."

Though the writer appears to see no incompatibility in these two conditions of the intellectual elevation of women, doubtless many of my readers will, particularly such of them as have borne and raised large families.

Herbert Spencer says: "Taking degree of nervous organization as the chief correlative of mental capacity, and remembering the physiological cost of that discipline whereby high mental capacity is reached, we may suspect that nervous organization is very expensive; the inference being that bringing it up to the level it reaches in man, whose digestive system, by no means large, has at the same time to supply materials for general growth and daily waste, involves a great retardation of maturity and sexual genesis." This is a general statement, applicable to the race as a whole, but it follows that, in so far as reproduction is a greater physical tax upon woman than upon man, so far she labors under a natural disability to equal man intellectually, there being a necessary antagonism between self-evolution and race-evolution, since energy expanded in one direction is not available in another.

Darwin, in suggesting a method—evidently impracticable, however—by which women may become the intellectual peers of men, fails to provide for the elevation of man to a moral equality with woman, although he admits that "the moral faculties are generally esteemed, and with justice, as of higher value than the intellectual powers." He says also that "the moral nature of man has reached the highest standard as yet attained, partly through the advancement of the reasoning powers and consequently of a just public opinion, but especially through the sympathies being rendered more tender and widely diffused."

In regard to the future progress of the race, Herbert Spencer asks "in what particular ways this further evolution, this higher life, this greater coördination of actions may be expected to show itself;" and concludes [1] that it will not be in the direction of increased muscular strength, but somewhat in an increase of mechanical skill, largely in intelligence, but most largely in morality.

Thus these high authorities assign to woman a place in the production of those influences which have developed and must continue to develop mankind, coextensive in importance with the moral interests of the race.

But, if I have read their teachings aright, neither man nor woman

[1] For argument, *see* "Principles of Biology," vol. ii., p. 495.

can justly take any individual pride, the one in his intellectual, the other in her moral superiority; rather they must see themselves as

> "Parts and proportions of a wondrous whole;"

as the accompanying movements which make up the harmony of the grand diapason of the human race.

And there is that just adaptation of the different parts which is essential to and constitutes harmony. Bacon says that the causes of harmony are equality and correspondence; and Pope completes our argument with the line—

> "All discord, harmony not understood."

There can be, then, no real conflict of interests between man and woman, since there is a mutual dependence of each upon the other, bringing mutual good. Neither can it be a misfortune to be a woman, as so many at the present day would have us believe, although her position may be in some respects subordinate to that of man.

In fact, the subordination of man to woman, different in kind from its converse, is equally apparent; both seem to be matters of common consciousness. It may be readily seen how, in early times, when muscular strength and general physical power were held in the highest esteem, that the position of woman should have been a subordinate one. Animal courage, endurance of physical hardships, the strength, cunning, and agility, which enabled men to cope with wild beasts and with each other, were the traits of character most prized, because most conservative of life in those barbarous times; hence the idea that, woman's position is naturally a subordinate one, has acquired the force of a primal intuition, and might almost be claimed as a "datum of consciousness." But, as the necessities of existence have been gradually modified by civilization, both the character and degree of her subordination have notably changed.

Those qualities, regarded as preëminently feminine, have risen in common estimation, and mere muscular superiority, and even intellectual power, are now put to the test of comparison with the higher moral qualities.

It is true that the laws of most countries still discriminate in a manner unfavorable to women. Legislation has been largely upon the ideal basis of every woman being under the protection of some man, and of all men being the true defenders of all women, and this is evidently traceable to the conviction, already alluded to, that a subordidate position belongs naturally to woman. Lecky says that "the change from the ideal of paganism to the ideal of Christianity was a change from a type which was essentially male to a type which was essentially feminine." As the race shall continue to approach the level of its lofty ideal, the subordination of woman, as well as that of man, will continue to lessen, since both have their chief foundation in the lower traits of character, the force in the one case being superior strength combined with power of will, and, in the other, superior beauty with the desire to fascinate. As these influences are gradually losing their power of despotic sway, woman, in place of acting as the slave, the toy, or the tyrant of man, is becoming not only his companion, but the custodian of the moral and religious interests of society, man looking at her as the natural critic and judge of the moral aspects of his conduct.

While the varying characteristics of the two sexes are thus seen to be inherent and inevitable (the secondary sexual characters having largely grown out of those which are primary and essential), it does not follow that they are necessarily indicative of the "sphere" of each for all time. While it is doubtless true, in a certain sense, that "that which has been is that which shall be," nevertheless, change (in accordance with law) underlies the very idea of evolution, and as it has been and is now, so it ever shall be, that the sphere of woman will be determined by the kind and degree of development to which she shall attain. Like man, she need know no other limitation; but when we look around upon the great industries of life, mining, engineering, manufacturing, commerce, and the rest, and consider how little direct agency woman has had in bringing them to their present stage of progress, we are compelled to believe that she must not look toward direct competition with man for the best unfolding of her powers, but, rather, while continuing to supplement him, as he does her, in the varied interests of their common life, that her future progress, as in the past, will consist mainly in the development of a higher character of womanhood through the selection and consequent intension of those traits peculiar to her own sex.

THE HERMIT OF RED-COAT'S GREEN.

By DANIEL H. TUKE, M.D., M.R.C.P.

EVERYBODY remembers Mopes, the "slothful, unsavory, nasty reversal of the laws of human nature"—Dickens's famous character of "Tom Tiddler's Ground." The recent death of the original of that sketch has attracted fresh notice to his strange mode of life. I propose to consider the question of his insanity; and whether, if insane, the mental disorder in this and similar cases calls for interference with the individual's liberty.

Mr. James Lucas, the fourth child of an opulent London merchant, was born in 1813; there were five children in all, of whom a brother and sister survive. He had an aunt who, like himself, exhibited a contempt for the ordinary decencies of civilized life, and an uncle who was also eccentric, though not in an asylum. Nothing is known of the previous generation, except that the paternal grandfather was successful in making money. Lucas was considered a healthy boy in mind and body up to ten years, when he suffered from a ringworm, and had his head shaved, and an ointment, said by a relative to have been very strong, rubbed in. His mother claimed that at this time his character underwent a change. She said that "he was never quite the same" afterward. Whether or not the implied cause[1] be deemed adequate, it is certain that an alteration in his moral character, marked chiefly by waywardness of temper and untruthfulness, occurred at this time. He was spoiled by both parents. It is a striking fact that very many of the patients admitted into York Retreat were unduly indulged when children.

At seven, he was sent to school. He ran away, but was sent back and kept there until he was fourteen. With a view to moral restraint and discipline, he was next sent to Mr. Hicks, a physician of Whitwell. His stay was short: one day during Mr. Hicks's absence, he escaped and took refuge with a relative, who refused to give him up. Mr. Hicks, who is still living, remembers the lad, and tells me that he regarded him as the victim of ill-judged indulgence and injudicious treatment.. He displayed "incorrigible perverseness and obstinacy, combined with a certain amount of cunning." Mr. Hicks learned nothing of his previous condition except that, when driven out for an airing, he would, if taken from the carriage, stand still and shut his eyes.

He returned home, but his father was totally unable to manage him. He was self-willed, obstinate, impatient of restraint. Thwarted in any of his wishes, he took offense, and shut himself in his bedroom for days together, spending therein, it seems, the greater part of his time. He would not refuse to eat his meals if they were left at his door, but he resolutely refused to return the plates, until, at length, his room contained nearly all the crockery in the house. At one time he would put on but little clothing; at another, dress like a fop. On account of these eccentricities, his father moved into the country, but shortly returned, as he there fell into low company and became less controllable. He next would not allow the cinders to be removed from his grate, thus keeping the family in constant dread that he would set the house on fire. He objected so much to an attendant, that one who had been procured was discharged.

At his seventeenth year his father died. At twenty, his conduct became unbearable, and by medical advice he was forced to have a constant attendant. This supervision, which lasted two years, showed how his state of mind was regarded by those competent to judge—

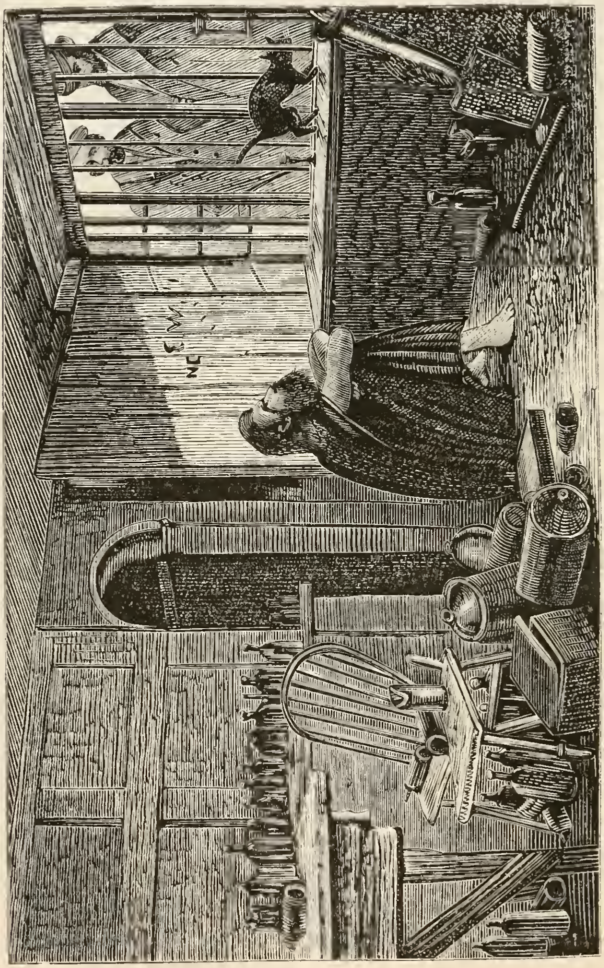
[1] Mr. Erasmus Wilson states that no case ever came to his knowledge of a mental affection resulting from local applications to the scalp. I find from Dr. Russell Reynolds, that he has had patients suffering from disorder of the emotions consequent on the use of hair-dyes.

the late Dr. Sutherland was one of the authorities consulted. It ceased only because his mother intensely disliked it. The family now lived at Red-Coat's Green, near Hitchen, in the house where the hermit afterward lived and died. He hunted occasionally with a gentleman of the neighborhood. He rode either with his shirt outside, or in a nankeen suit, barefooted, with a small cap, or bareheaded, his long hair streaming in the wind. He bestrode a high-peaked saddle, and used a rope for his bridle and stirrups. Sometimes, he would ride in a carriage, his hair done up in curl-papers. He became attentive to a young lady, to whom he sent a pair of doves in a cage, but she returned the present. He persecuted her sadly, by prowling around the house. His mother died in 1849. He was then the eldest surviving son, but a younger one was left executor. A fatal objection to his acting in that capacity was, that he would not sign his name to any paper bearing her Majesty's stamp. He held that she was not the rightful heir to the throne, and would not use a postage or receipt stamp lest he should seem to admit her supremacy. But he did not scruple to use a coin bearing her image.

He kept his mother's body in the house from the 24th of October, 1849, to January, 1850, promising each day to let her be buried "to-morrow." The greater part of his time was spent beside the corpse. At length his brother interfered and buried the body. It has been published that he was heart-broken at his mother's death. His relatives doubt the depth of this attachment. He, indeed, expressed himself as much attached to her, and intimated that he would die with her; but she often said that he never showed his affection by gratifying one of her wishes. However, he may have felt real sorrow at her death, and this seems to be implied by the fact that he allowed things in the house to remain just as they were when she died; her letters and money untouched, and the beds as they were then made. In fact, his distress seemed genuine. He often told a neighbor that he would willingly have died for her, and he would weep bitterly at the mention of her name.

His life as a hermit now began, but, however great his distress, we cannot attribute to it his strange mode of life. His brother believes that he afterward appeared worse only because all restraint was removed. His brother and sisters could not now live with him. I believe he never saw the latter again, while he became estranged from the former because of his interference about the interment. Lucas spoke in the bitterest terms of his brother, and even left a hay-stack untouched, all his life alleging that he would hold him responsible for it. Still, his brother visited him several times, and was received. It is important to observe that he made a will a few years after his mother's death, wherein he evinced no animosity toward his brother, nor displayed any eccentricity in the disposition of his property. The appearance of the house bespoke the character of the occupant. Windows and doors were carefully barricaded, and the house was allowed to go to ruin; so likewise was the garden. A tree which fell across the walk was not cleared away except to allow a passage to the house.

I visited the hermit some years ago, going up to the window of what had been the kitchen. Glass and casement had long disappeared;



Portrait of the Hermit.

the strong upright iron bars alone remained. Here the possessor of ample means, a man of at least fair education, lived day and night. He appeared to emerge from a bed of ashes.[1] He had not slept in a bed for many years. He came forward, and entered, rather reluc-

[1] I observed that, when his room was entered after death, the floor was found to be covered two or more feet with cinders that had accumulated. A farmer informs me that he has since removed fourteen cart-loads of cinders from the house and around it.

tantly, into conversation, with a suspicious expression. Unwashed for many years, his skin was in an undesirable condition, the whites of his eyes contrasting strangely with the rest of his face. Clothes he had none; only a dirty blanket loosely thrown over him. His hair, long a stranger to scissors or razor, was matted with dirt. He was about five feet six inches high, rather muscular, with dark hair and eyes, the latter prominent, and pale complexion. His forehead appeared well developed. The room had a fire, an old table, a chair, and numerous bottles. It is said he suspended a basket from the ceiling to keep his food from the rats. He spoke to me in a low, rather plaintive tone, which impressed me that he was laboring under a certain amount of fear or apprehension. Part of his conversation, otherwise perfectly rational, conveyed the same impression. He intimated that his relations were against him, and I understood him to assign it as the reason why his house was barricaded. He appeared to be laboring under a partial insanity—a monomania of suspicion or persecution. Whatever reasons he may have subsequently had for barricading his house, his brother informs me that some panes of glass were actually broken by stones during the papal aggression in 1850, because he leaned to Romanism, and then it was that bars of wood were nailed across the windows.

He wrote no letters, nor wrote at all, that I know of, except upon a check. He had a check-book and used it to pay some of his bills. When he required money, his bankers received a verbal message, and sent a clerk to transact business with him. The check was always very correctly written, and the counterfoil duly filled in. On his last check, dated April 14, 1874, the signature, unlike the previous ones, was rather shaky. Because of his antipathy to stamps, the receipt-stamp had to be added afterward. The dividend-warrants that came to him remained uncashed for the same reason, forming a large collection of very dirty papers. About four years ago he was induced to authorize his bankers to receive his dividends, and thus surmounted his scruple to recognize the queen. Landed property of his at Liverpool, required for public purposes, was sold under compulsion because he would not become a party to the sale, as it involved the use of a stamp. The money was placed in the Bank of England, and remained there to his death, because he would not use a stamp to draw it out. I have a curious proof of his shrewdness and desire to get the money. A solicitor he knew had some connection with the Court of Chancery. One day he suggested to him to file a bill in chancery to obtain the money. His visitor replied that the court would then institute an inquiry into the condition of the owner. "What!" asked Lucas, alarmed, "do you mean *de lunatico?*" An affirmative answer killed the scheme.

Lucas was not a miser. He gave to swarms of tramps, in coppers and gin, giving always more to a Romanist than a Protestant. It is said that on last Good Friday he doled out sweetmeats, coppers, gin-and-water (large quantities of which he always kept on hand) to two hundred children. For some years he gave a poor old woman four shillings a week. His diet was simple, though not scant. He ate bread, cheese, and red herrings, and drank both milk and gin. Once, however, he gave up milk—and this, of course, is an important feature of his case—because he suspected that poison had been put into it. At one time he charged a farmer who supplied him with eggs with putting poison into them. When the farmer replied that it would be rather a difficult thing to do, he said that some poison must have been given to the *old hen.* He did not habitually drink to excess, but was occasionally drunk. It is supposed that he drank largely of gin the evening before his death, while feeling depressed. Fear of poison frequently led him to change his baker, and he carefully selected a loaf. In his room was found nearly a cart-load of loaves which he probably suspected of containing poison.

He died of apoplexy at sixty-one, on the 19th of April last. A week before his death he appeared as well as usual; he was, in fact, lively and communicative, and seemingly without any unfriendly spirit or delusion regarding his friends. He spoke with an asthmatic visitor very intelligently of the symptoms and causes of that disease. He remembered the number of years (seven) since he had seen him, and the subject discussed, which the visitor had forgotten. Sometimes, however, he complained of losing his memory, and it was noticed latterly that in using a Greek word—he partially remembered both Greek and Latin—he could not recall the whole of it, and, contrary to his custom, would be at a loss for a word. One who frequently visited him says that he was sometimes low-spirited, crying like a child, bemoaning his condition, and attributing it to the unkindness of his brother, which I know to be entirely false. At other times, if contradicted, he would fly into a passion, swear, and act so violently that his guest would be glad to get out of the house. Because, while this visitor was present once, a medical man happened to call, he quarreled with him, and suspected the two of a conspiracy.

That there was no imbecility of mind may at once be granted. His conversation was coherent and sensible; he was shrewd and wide awake in the ordinary transactions of his limited life, and he fully understood the value of money; his memory was remarkably retentive.[1] Most of his visitors failed to detect any signs of madness, and it is doubtful whether any jury would have found him insane. The commissioners considered his case in 1853, and took the testimony of his brother and a neighbor, but concluded that there was not sufficient

[1] One of his visitors, a traveled man, was surprised to find that Lucas had so much acquaintance with the various localities which turned up in conversation. His knowledge of Shakespeare and of the literature of the Restoration was very considerable. A medical man informs me that, in conversing with him about the classics, he displayed much intelligence.

evidence to warrant an interference. Mr. Forster saw the hermit last year, and found him singularly acute, without the least trace of mental aberration. He said to that gentleman: "You may think it strange my living like this. So do I sometimes, but it is not done without a reason." Nor could Forster's friend, Dickens, recognize the signs of madness in his behavior.

On the other hand, there is the family history pointing to hereditary predisposition to insanity, only wanting some exciting cause to develop it; also the change of character at ten, with an alleged physical cause; the action, as a moral cause, of an injuriously indulgent rearing; the constant waywardness, obstinate willfulness, in a word, wrongheadedness; the acts which frequently alarmed his family; the necessity at length of legal restraint; the freaks regarding dress; his extraordinary conduct on the death of his mother; the persistent delusion respecting the queen, involving much loss of property; the entire neglect of his dwelling and person; his groundless suspicion of and antipathy toward his brother; the delusion that poison was put into his food; his fits of mental depression; and his violent passion on the slightest contradiction. These characteristics—in many respects so familiar to us in asylum-life, and so easily conceivable in others if certain cases of insanity we have known had been allowed to develop—prove that the hermit's condition passed the limits of eccentricity, that his emotions were perverted by disease. But, while his case was primarily one of moral insanity—a madness of action rather than language, a state of degraded feeling rather than of intellectual incapacity—his suspicions at times took the form of a definite delusion. It should be carefully borne in mind that his isolated life, and neglect of his residence and dress, did not arise from the preoccupation of his thoughts by any absorbing pursuit. He had none. It arose from his diseased mental condition, and the solution of the problem of his life can be obtained only *by tracing back his history to the unfavorable circumstances of his childhood, acting upon a brain in all probability predisposed to disease.*

Should such a man be interfered with? Interference could not be made on account of the neglect of his property, or of his mode of life. But, conceding his insanity, would it have been desirable to place him under care? He was harmless to others, and also to himself, except in a very general sense; but might he not have been benefited and really more comfortable under medical treatment and control? And answering, as I think this case did, the definition of the law, that there must be "demonstrative proof of the incapacity of the individual to be trusted with himself and his own concerns," it certainly would have saved a great deal of trouble, had he been under the protection of the lord chancellor. I submit that such control would have been better for the neighborhood, for his family, and for the hermit himself.

ADDRESS BEFORE THE AMERICAN ASSOCIATION.[1]

By Prof. JOSEPH LOVERING.

II.

Mathematical Investigations in Physics.

I AM thus suddenly brought face to face with the second head of my subject: the mathematical and philosophical state of the physical sciences.

The luminiferous ether and the undulatory theory of light have always troubled what is supposed to be the imperturbable character of the mathematics. The proof of a theory is indisputable when it can predict consequences, and call successfully upon the observer to fulfill its prophecies. It is the boast of astronomers that the law of gravitation thus vindicates itself. The undulatory theory of light has shown a wonderful facility of adaptation to each new exigency in optics, and has opened the eye of observation to see what might never have been discovered without the promptings of theory. But this doctrine, and that of gravitation also, have more than once been arrested in their swift march and obliged to show their credentials. After Fresnel and Young had secured a firm foothold for Huyghens's theory of light in mechanics and experiment, questions arose which have perplexed, if not baffled, the best mathematical skill. How is the ether affected by the gross matter which it invests and permeates? Does it move when they move? If not, does the relative motion between the ether and other matter change the length of the undulation or the time of oscillation? These queries cannot be satisfactorily answered by analogy, for analogy is in some respects wanting between the ether and any other substance. Astronomy says that aberration cannot be explained unless the ether is at rest. Optics replies that refraction cannot be explained unless the ether moves. Fresnel produced a reconciliation by a compromise. The ether moves with a *fractional* velocity large enough to satisfy refraction, but too small to disturb sensibly the astronomer's aberration. In 1814, Arago reported to Fresnel that he found no sensible difference in the prismatic refraction of light, whether the earth was moving with full speed toward a star or in the opposite direction, and asked for an explanation. Fresnel submitted the question to mathematical analysis, and demonstrated that, whatever change was produced by the motion of the prism in the relative velocity of light, the wave-length in the prism, and the refraction, was compensated by the physiological aberration when the rays emerged. Very recently, Ketteler, of Bonn, has

[1] Retiring Address before the American Association for the Advancement of Science at the Hartford meeting, August 14, 1874, by the ex-President.

gone over the whole ground again with great care, studying not only Arago's case but the general one, in which the direction of the light made any angle with the motion of the earth; and he proves that the light will always enter the eye in the same apparent direction as it would have done if the earth were at rest. The mathematical and physical view taken of this subject by Fresnel has been under discussion for sixty years, and forty eminent physicists and mathematicians might be enumerated who have taken part in it. Fresnel's explanation has encountered difficulties and objections. Still, it is consistent not only with Arago's negative result, but with the experiments on diffraction by Fizeau and Babinet, and the preponderance of mathematical evidence is on that side. Mr. Huggins runs counter to the general drift of physical and algebraical testimony (although he appears to be sustained by the high authority of Maxwell), when he attributes some displacement of the spectrum-lines to the motion of the earth, and qualifies the observed displacement on that account. The number of stars which Huggins has observed is insufficient for any sweeping generalization. And yet he seems inclined to explain the revelations of his spectroscope, not by the motion of the stars, but by that of the solar system; because those stars which are in the neighborhood of the place in which astronomers have put the solar apex are moving, apparently, toward the earth, while those in the opposite part of the sky recede. If it be true that the earth's annual motion produces no displacement in the spectrum, then the motion of the solar system produces none. Or, waiving this objection, if the correct explanation has been given by Huggins, astronomers have failed, by their geometrical method, of rising to the full magnitude of the sun's motion. The discrepancy appears to awaken no distrust in Mr. Huggins's mind as to the delicacy of the spectrum analysis or the mathematical basis of his reasoning. On the contrary, he would remove the discrepancy by throwing discredit on the estimate of star-distances made independently by Struve and Argelander from different lines of thought.

Next, we ask, if it is certain that even the motion of the luminary will change the true wave-length, the period of oscillation, and the refrangibility, of the light which issues from it. The commonly-received opinion on this subject has not been allowed to pass unchallenged. It is fortified by more than one analogy; but it is said that comparison is not always a reason. It is not denied that, when the sonorous body is approaching, the sound-waves are shortened, the number of impulses on the ear by the condensed air is increased, and the pitch of the sound is raised. Possibly, the color of light would follow the same law; but there is no experiment to prove it, and very little analogy exists between the eye and the ear. There is no analogy, whatever, between the subjective sensation by either organ and the physical action of the prism. The questions at issue are these: Does refraction depend upon the absolute or the relative velocity of light; are the time of oscillation of the particles of ether and the normal wave-length, corresponding to it, changed by any motion of translation in the origin; or is the conservation of these elements an essential attribute of the luminiferous medium? It has been said that Doppler reasoned as if the corpuscular theory of light were true, and then expressed himself in the language of undulations. Evidently there is an obscurity in the minds of many physicists, and an uncertainty in all, when they reason upon the mechanical constitution of the ether, and the fundamental laws of light. The mathematical theory is not so clear as to be able to dispense with the illumination of experiment. Within the present year, Van der Willigen has published a long and well-considered memoir on the theoretical fallacies which vitiate the whole of Huggins's argument for the motion of the stars and nebulæ. His analysis proves that the motion of the luminary will not interfere with the time of oscillation and the wave-length, provided that the origin of the disturbance is not a mathematical point but a vibrating molecule, and that the sphere of action of this molecule upon surrounding molecules is large enough to keep them under its influence during ten or a hundred vibrations, before it is withdrawn by the motion of translation. If this theoretical exposition of the subject should be generally adopted by mathematicians, the spectroscopic observations on the supposed motion of the stars must receive another interpretation. On the other hand, if a luminary is selected which is known to move, independently of spectroscopic observations, and the displacement of the spectrum-lines accords with this motion, it will be time to reconsider the mathematical theory, and make our conceptions of the ether conform to the experiment. The spectroscopic observation of Angström on an oblique electric spark does not favor Huggins's views. Secchi testifies to opposite displacements when he examined, with a direct-vision spectroscope, the two edges of the sun's equator, one of which was rotating toward him and the other from him, and Vogel has repeated the observation with a reversion spectroscope. This would have the force of a crucial experiment, were it not that an equal displacement was seen on other parallels of latitude, and that the bright bands of the chromosphere were moved, but not the dark lines of the solar atmosphere.

When Voltaire visited England in 1727, he saw at the universities the effect of Newton's revolutionary ideas in astronomy. The mechanism of gravitation had exiled the fanciful vortices of Descartes, which were still circulating on the Continent. So he wrote: "A Frenchman who comes to London finds many changes in philosophy as in other things: he left the world full, he finds it empty." The same comparison might be made now, not so much between nationalities as between successive stages of scientific development. At the beginning of this century the universe was as empty as an exhausted receiver: now it has filled up again. Nature's abhorrence of a vacuum has been resuscitated, though for other reasons than those which satisfied the Aristotelians. It is the mathematicians and not the metaphysicians who are now discussing the relative merits of the *plenum* and the *vacuum*. Newton, in his third letter to Bentley, wrote in this wise: "That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance, through a *vacuum*, without the mediation of any thing else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it." Roger Cotes, who was Newton's successor in the chair of Mathematics and Natural Philosophy at Cambridge, was only four years old when the first edition of the "Principia" was issued, and Newton outlived him by ten years. The venerable teacher pronounced upon the young mathematician, his pupil, these few but comprehensive words of eulogy: "If Cotes had lived, we should have known something." The view taken of gravitation by Cotes was not the same as that held by his master. He advocated the proposition that action at a distance must be accepted as one of the primary qualities of matter, admitting of no further analysis. It was objected by Hobbes and other metaphysicians, that it was inconceivable that a body should act where it was not. All our knowledge of mechanical forces is derived from the conscious effort we ourselves make in producing motion. As this motion employs the machinery of contact, the force of gravitation is wholly outside of all our experience. The advocates of action at a distance reply that there is no real contact in any case, that the difficulty is the same with the distance of molecules as that of planets, that the mathematics are neither long-sighted nor short-sighted, and that an explanation which suits other forces is good enough for gravitation.

Comte extricated himself from this embarrassment by excluding causes altogether from his positive philosophy. He rejects the word attraction as implying a false analogy, inconsistent with Newton's law of distance. He substitutes the word gravitation, but only as a blind expression by which the facts are generalized. According to Comte's philosophy, the laws of Newton are on an equality with the laws of Kepler, only they are more comprehensive, and the glory of Kepler has the same stamp as that of Newton. Hegel, the eminent German metaphysician, must have looked at the subject in the same light when he wrote these words: "Kepler discovered the laws of free motion; a discovery of immortal glory. It has since been the fashion to say that Newton first found out the truth of these rules. It has seldom happened that the honor of the first discoverer has been more unjustly transferred to another." Schelling goes further in the same direction: he degrades the Newtonian law of attraction into an empirical fact, and exalts the laws of Kepler into necessary results of our ideas.

Meanwhile, the Newtonian theory of attraction, under the skillful generalship of the geometers, went forth on its triumphal march through space, conquering great and small, far and near, until its empire became as universal as its name. The whirlpools of Descartes offered but a feeble resistance, and were finally dashed to pieces by the artillery of the parabolic comets; and the rubbish of this fanciful mechanism was cleaned out as completely as the cumbrous epicycles of Ptolemy had been dismantled by Copernicus and Kepler. The mathematicians certified that the solar system was protected against the inroads of comets, and the border warfare of one planet upon another, and that its stability was secure in the hands of gravitation, if only space should be kept open, and the dust and cobwebs which Newton had swept from the skies should not reappear. Prophetic eyes contemplated the possibility of an untimely end to the revolution of planets, if their ever-expanding atmospheres should rush in to fill the room vacated by the maelstroms of Descartes. When it was stated that the absence of infinite divisibility in matter, or the coldness of space, would place a limit upon expansion, and, at the worst, that the medium would be too attenuated to produce a sensible check in the headway of planets; and when, in more recent times, even Encke's comet showed but the slightest symptoms of mechanical decay, it was believed that the motion was, in a practical, if not in a mathematical sense, perpetual. Thus it was that the splendors of analysis dimmed the eyes of science to the intrinsic difficulties of Newton's theory, and familiarity with the language of attraction concealed the mystery that was lurking beneath it. A long experience in the treatment of gravitation had supplied mathematicians with a fund of methods and formulas suited to similar cases. As soon as electricity, magnetism, and electro-magnetism took form, they also were fitted out with a garment of attractive and repulsive forces acting at a distance; and the theories of Cavendish, Poisson, Aepinus, and Ampère, indorsed as they were by such names as Laplace, Plana, Liouville, and Green, met with general acceptance.

The seeds, which were destined to take root in a later generation, and disturb, if not dislodge, the prevalent interpretation of the force of gravitation, were sown by a contemporary of Newton. They found no congenial soil in which they could germinate and fructify until the early part of the present century. At the present moment, we find the luminiferous ether in quiet and undivided possession of the field from which the grosser material of ancient systems had been banished. The *plenum* reigns everywhere; the vacuum is nowhere. Even the corpuscular theory of light, as it came from the hands of its founder, required the reënforcement of an ether. Electricity and magnetism, on a smaller scale, applied similar machinery. If there was a fundamental objection to the conception of forces acting at a distance, certainly the bridge was already built by which the difficulty could be surmounted. The turning-point between the old physics and the new physics was reached in 1837, when Faraday published his experiments on the specific inductive capacity of substances. This discovery was revolutionary in its character, but it made no great stir in science at the time. The world did not awake to its full significance until the perplexing problem of ocean-telegraphs converted it from a theoretical proposition into a practical reality, and forced it on the attention of electricians. The eminent scientific advisers of the cable companies were the first to do justice to Faraday. This is one of the many returns made to theoretical electricity for the support it gave to the most magnificent commercial enterprise.

The discovery of diamagnetism furnished another argument in favor of the new interpretation of physical action. What that new interpretation was, is well described by Maxwell: "Faraday, in his mind's eye, saw lines of force traversing all space, where the mathematicians saw centres of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a *power* of action at a distance impressed on the electric fluids." The physical statement waited only for the coming of the mathematicians who could translate it into the language of analysis, and prove that it had as precise a numerical consistency as the old view with all the facts of observation. A paper published by Sir William Thomson, when he was an undergraduate at the University of Cambridge, pointed the way. Prof. Maxwell, in his masterly work on electricity and magnetism, which appeared in 1873, has built a monument to Faraday, and unconsciously to himself also, out of the strongest mathematics. For forty years mathematicians and physicists had labored to associate the laws of electro-statics and electro-dynamics under some more general expression. An early attempt was made by Gauss in 1835, but his process was published, for the first time, in the recent complete edition of his works. Maxwell objects to the formula of Gauss because it violates the law of the conservation of energy. Weber's method was made known in 1846; but it has not escaped the criticism of Helmholtz. It represents faithfully the laws of Ampère and the facts of induction, and led Weber to an absolute measurement of the electro-static and electro-magnetic units. The ratio of these units, according to the formulas, is a velocity; and experiment shows that this velocity is equal to the velocity of light. As Weber's theory starts with the conception of action at a distance, without any mediation, the effect would be instantaneous, and we are at a loss to discover the physical meaning which he attaches to his velocity. Gauss abandoned his researches in electromagnetism because he could not satisfy his mind in regard to the propagation of its influence in time. Other mathematicians have worked for a solution, but have lost themselves in a cloud of mathematical abstraction. The two theories of light have exhausted all imaginable ways in which force can be gradually transmitted without increase or loss of energy. Maxwell cut the Gordian knot when he selected the luminiferous ether itself as the arena on which to marshal the electro-magnetic forces under the symbols of his mathematics, and made light a variety of electro-magnetic action. His analysis gave a velocity essentially the same as that of Weber, with the advantage of being a physical reality and not a mere ratio. Of the two volumes of Mr. Maxwell, freighted with the richest and heaviest cargo, the reviewer says: "Their author has, as it were, flown at every thing: and, with immense spread of wing and power of beak, he has hunted down his victims in all quarters, and from each has extracted something new and interesting for the intellectual nourishment of his readers." Clear physical views must precede the application of mathematics to any subject. Maxwell and Thomson are liberal in their acknowledgments to Faraday. Mr. Thomson says: "Faraday, without mathematics, divined the result of the mathematical investigation; and, what has proved of infinite value to the mathematicians themselves, he has given them an articulate language in which to express their results. Indeed, the whole language of the *magnetic field* and *lines of force* is Faraday's. It must be said for the mathematicians that they greedily accepted it, and have ever since been most zealous in using it to the best advantage."

It is not expected that the new views of physics will be generally accepted without vigorous opposition. A large amount of intellectual capital has been honestly invested in the fortunes of the other side. The change is recommended by powerful physical arguments, and it disenthralls the theories of science from many metaphysical difficulties which weigh heavily on some minds. On the other hand, the style of mathematics which the innovation introduces is novel and complex; and good mathematicians may find it necessary to go to school again before they can read and understand the strange analysis. It is feared that, with many who are not easily deflected from the old ruts, the intricacies of the new mathematics will outweigh the superiority of the new physics.

The old question, in regard to the nature of gravitation, was never settled: it was simply dropped. Now it is revived with as much earnestness as ever, and with more intelligence. Astronomy cast in its own mould the original theories of electrical and magnetic action. The revolution in electricity and magnetism must necessarily react upon astronomy. It was proved by Laplace, from data which would now, probably, require a numerical correction, that the velocity of the force of gravitation could not be less than eight million times the velocity of light; in fact, that it was infinite. Those who believe in action at a distance cannot properly speak of the transmission of gravitation. Force can be transmitted only by matter: either with it or through it. According to their view, action at a distance *is* the force, and it admits of no other illustration, explanation, or analysis. It is not surprising that Faraday and others, who had lost their faith in action at short distances, should have been completely staggered by the ordinary interpretation of the law of gravitation, and that they declared the clause which asserted that the force diminished with the square of the distance to be a violation of the principle of the conservation of force.

Must we, then, content ourselves with the naked facts of gravitation, as Comte did, or is it possible to resolve them into a mode of action, in harmony with our general experience, and which does not shock our conceptions of matter and force? In 1798, Count Rumford wrote thus: "Nobody surely, in his sober senses, has ever pretended to understand the mechanism of gravitation." Probably Rumford had never seen the paper of Le Sage, published by the Berlin Academy in 1782, in which he expounded his mechanical theory of gravitation, to which he had devoted sixty-three years of his life. In a posthumous work, printed in 1818, Le Sage has developed his views more fully. He supposed that bodies were pressed toward one another by the everlasting pelting of ultra-mundane atoms, inward bound from the immensity of space beyond, the faces of the bodies which looked toward each other being mutually screened from this bombardment. It was objected to this hypothesis, which introduced Lucretius into the society of Newton and his followers, that the collision of atoms with atoms, and with planets, would cause a secular diminution in the force of gravity. Le Sage admitted the fact. But, as no one knew that the solar system was eternal, the objection was not fatal. As the necessity for giving a mechanical account of gravitation was not generally felt at the time, the theory of Le Sage fell into oblivion. In 1873, Sir William Thomson resuscitated and republished it. He has fitted it out in a fashionable dress, made out of elastic molecules instead of hard atoms, and has satisfied himself that it is consistent with modern thermo-dynamics and a perennial gravitation.

Let us now look in a wholly different quarter for the mechanical origin of gravitation. In 1870 Prof. Guthrie gave an account of a novel experiment, viz., the attraction of a light body by a tuning-fork when it was set in vibration. Thomson repeated the experiment upon a suspended egg-shell, and attracted it by a simple wave of the hand. Thomson remarks that "what gave the great charm to these investigations, for Mr. Guthrie himself, and no doubt also for many of those who heard his expositions and saw his experiments, was, that the results belong to a class of phenomena to which we may hopefully look for discovering the mechanism of magnetic force, and possibly also the mechanism by which the forces of electricity and gravity are transmitted." By a delicate mathematical analysis, Thomson arrives at the theorem that the "average pressure at any point of an incompressible, frictionless fluid, originally at rest, but set in motion and kept in motion by solids, moving to and fro, or whirling round in any manner, through a finite space of it," would explain the attractions just described. Moreover, he is persuaded by other effects besides those of light, that, in the interplanetary spaces and in the best artificial vacuum, the medium which remains has "perfectly decided mechanical qualities, and, among others, that of being able to transmit mechanical energy, in enormous quantities:" and he cherishes the hope that his mathematical theorems on abstract hydrokinetics are of some interest in physics as illustrating the great question of the eighteenth and nineteenth centuries: Is action at a distance a reality, or is gravitation to be explained, as we now believe magnetic and electric forces must be, by action of intervening matter?

In 1869 and 1873, Prof. Challis, of Cambridge, England, published two works on the "Principles of Mathematical Physics." They embody the mature reflections of a mathematical physicist at the advanced age of threescore years and ten. Challis believes that there is sufficient evidence for the existence of ether and atoms as physical realities. He then proceeds to say: "The fundamental and only admissible idea of *force* is that of *pressure*, exerted either actively by the ether against the surface of the atoms, or as reaction of the atoms on the ether by resistance to that pressure. The principle of deriving fundamental physical conceptions from the indications of the senses does not admit of regarding *gravity*, or any other force varying with distance, as an essential quality of matter, because, according to that principle, we must, in seeking for the simplest idea of physical force, have regard to the sense of *touch*. Now, by this sense, we obtain a perception of force as pressure, distinct and unique, and not involving the variable element of distance, which enters into the perception of force as derived from the sense of sight alone. Thus, on the ground of simplicity as well as of distinct perceptibility, the fundamental idea of force is pressure." As all other matter is passive except when acted upon by the ether, the ether itself, in its quiescent state, must have uniform density. It must be coextensive with the vast regions in which material force is displayed. Challis had prepared himself for the elucidation and defense of his dynamical theory by a profound study of the laws of motion in elastic fluids. From the mathematical forms in which he has expressed these laws he has attempted to derive the principal experimental results in light, heat, gravitation, electricity, and magnetism. Some may think that Mr. Challis has done nothing but clothe his theory in the cast-off garments of an obsolete philosophy. If its dress is old, it walks upon new legs. The interplay between ether and atoms is now brought on to the stage, not as a speculation supported by metaphysical and theological arguments, but as a physical reality with mathematical supports. I should do great injustice to this author if I left the impression that he himself claimed to have covered the whole ground of his system by proof. Mathematical difficulties prevented him from reaching a numerical value for the resultant action of a wave of ether upon the atom. What he has written is the guide-post, pointing the direction in which science is next to travel; but the end of the journey is yet a great way off. The repeated protests of Mr. Challis against the popular physics of the day, and his bold proclamation of the native, independent motion of the ether, have aroused criticism. What prevents the free ether, asks the late Sir John Herschel, from expanding into infinite space? Mr. Challis replies that we know nothing about infinite space or what happens there, but the existence of the ether, where our experience can follow it, is a physical reality. The source of the motion which the ether acquires is not the sun; for the most efficient cause of solar radiation is gravitation and condensation. Our author avoids the vicious circle of making gravitation, first the reason and afterward the consequence of the motion of the ether. He says: "It follows that the sun's heat, and the heat of masses in general, are stable quantities, oscillating, it may be, like the planetary motions, about *mean* values, but never permanently changing, so long as the Upholder of the universe conserves the force of the ether and the qualities of the atoms. There is no law of destructibility; but the same Will that conserves can in a moment destroy." The following remarks upon this theory deserve our attention: "The explanation of any action between distant bodies by means of a clearly conceivable process, going on in the intervening medium, is an achievement of the highest scientific value. Of all such actions that of gravitation is the most universal and the most mysterious. Whatever theory of the constitution of bodies holds out a prospect of the ultimate explanation of the process by which gravitation is effected, men of science will be found ready to devote the whole remainder of their lives to the development of that theory."

The hypotheses of Challis and Le Sage have one thing in common: the motion of the ether and the driving storm of atoms must come from outside the world of stars. "On either theory, the universe is not even temporarily automatic, but must be fed from moment to moment by an agency external to itself." Our science is not a finality. The material order which we are said to know makes heavy drafts upon an older or remoter one, and that, again, upon a third. The world, as science looks at it, is not self-sustaining. We may abandon the hope of explaining gravitation, and make attraction itself the primordial cause. Our refuge then is in the sun. When we qualify the conservation of energy by the dissipation of energy, the last of which is as much an induction of science as the first, the material fabric which we have constructed still demands outward support. Thomson calculates that, within the historical period, the sun has emitted hundreds of times as much mechanical energy as is contained in the united motions of all the planets. This energy, he says, is dissipated more and more widely through endless space, and never has been, probably never can be, restored to the sun, without acts as much beyond the scope of human intelligence as a creation or annihilation of energy, or of matter itself, would be.

From the earliest dawn of intellectual life, a general theory of the constitution of matter has been a fruitful subject of debate, and human science and philosophy have ever been dashing their heads against the intractable atoms. The eagerness of the discussion was the greater, the more hopeless the solution. For every man who set up an hypothesis upon the subject, there were half a dozen others to knock it down; until at last speculation, which bore no fruit, was suspended. A lingering interest still hung around the question, whether matter was not infinitely divisible, and the atomic philosophers were not chasing a chimera. From every new decision on this single point there was an appeal, and the foothold which the atoms had secured in chemistry was gradually subsiding. Of a sudden, the atomic theory has gained a new lease of life. But the hero of the new drama is not the atom, but the molecule. In all the physical sciences, including astronomy, the war has been carried home to the molecules; and the intellectual victories of this and the next generation will be on this narrow field. From the outlying provinces of physics; from the sun, the stars, and the nebulæ; from the comets and meteors; from the zodiacal light and the aurora; from the exquisitely tempered and mysterious ether—the forces of Nature have been moving in converging lines to this common battle-ground, and some shouts of victory have already been heard. In the long and memorable controversy between Newton and Leibnitz, and their adherents, as to the true measure of force, it was charged against the Newtonian rule that force was irrecoverably lost whenever a collision occurred between hard, inelastic bodies. The answer was, that Nature had anticipated the objection, and had avoided this kind of matter. Inelastic bodies were yielding bodies, and the force which had disappeared from the motion had done its work in changing the shape. But, unless the body could recover its original figure by elasticity, there was no potential energy, and force was annihilated. It is now believed, and to a large extent demonstrated, that the force, apparently lost, has been transformed into heat, electricity, or some other kind of molecular motion, of which the change of shape is only the outward sign. The establishment on a firm foundation of theory and experiment of the so-called conservation of energy, the child of the correlation of physical forces, is one of the first fruits of molecular mechanics.

It is no disparagement of this discovery, on which was concentrated the power of several minds, to call it an extension, though a vast one, of Newton's law of inertia, of Leibnitz's *vis viva*, and of Huyghens's and Bernouilli's conservation of living forces; these older axioms of mechanics having free range only in astronomy, where friction, resistance, and collision, do not interfere. The conservation of energy, in its extended signification, promises to be, like its forerunners, a valuable guide to discovery, especially in the dark places into which physical science has now penetrated. The caution which Lagrange has given in reference to similar mechanical principles, such as the conservation of the motion of the centre of gravity, the conservation of moments of rotation, the preservation of areas, and the principle of least action, is not without its applicability to the new generalization. Lagrange accepts them all as results of the known laws of mechanics, and not as the essence of the laws of Nature. The most that physical science can assert is, that it possesses no evidence of the destructibility of matter or force.

It is not pretended that the existence of atoms has been or can be proved or disproved. Some chemists think that the atomic theory is the life of chemistry; others have abandoned it. Its importance is lost in that of the molecular theory. And what has this accomplished to justify its existence? If we define the molecule of any substance as the smallest mass of that substance which retains all its chemical properties, we can start with the extensive generalization of Avogadro and Ampère, that an equal volume of every kind of matter in the state of vapor, and under the same pressure and temperature, contains an equal number of such molecules. The conception of matter as consisting of parts, which are perpetually flying over their microscopic orbits, and producing by their fortuitous concourse all the observed qualities of bodies, is as old as Lucretius. He saw the magnified symbol of his hypothesis in the motes which chase one another in the sunbeam. One of the Bernouillis thought that the pressure of gases might be caused by the incessant impact of these little masses on the vessel which held them. The discovery that heat was a motion and not a substance, foreshadowed by Bacon, made probable by Rumford and Davy, and rigidly proved by Mayer and Joule when they obtained its exact mechanical equivalent, opened the way to the dynamical theory of gases. Joule calculated the velocity of this promiscuous artillery, rendered harmless by the minuteness of the missiles, and found that the boasted guns of modern warfare could not compete with it. Clausius consummated the kinetic theory of gases by his powerful mathematics, and derived from it the experimental laws of Mariotte, Gay-Lussac, and Charles. By the assumption of data, more or less plausible, several mathematicians have succeeded in computing the sizes and the masses of the molecules and some of the elements of their motion. It should not be forgotten that mathematical analysis is only a rigid system of logic by which wrong premises conduct the more surely to an incorrect conclusion. To claim, for all the conclusions which have been published in relation to the molecules, the certainty which fairly belongs to some of them, would prejudice the whole cause.

One of the most interesting investigations in molecular mechanics was published by Helmholtz in 1858. It is a mathematical discussion of what he calls ring-vortices, in a perfect, frictionless fluid. Helmholtz has demonstrated that such vortices possess a perpetuity and an inviolability once thought to be realized only by the eternal atoms. The ring-vortices may hustle one another, and pass through endless transformations; but they cannot be broken or stopped. Thomson seized upon them as the impersonation of the indestructible but plastic molecule which he was looking for, to satisfy the present condition of physical science. The element of the new physics is not an atom or a congeries of atoms, but a whirling vapor. The molecules of the same substance have one invariable and unchangeable mass; they are all tuned to one standard pitch, and, when incandescent, emit the same kind of light. The music of the spheres has left the heavens and condescended to the rhythmic molecules. There is here no birth, or death, or variation of species. If other masses than the precise ones which represent the elements have been eliminated, where, asks Maxwell, have they gone? The spectroscope does not show them in the stars or nebulæ. The hydrogen and sodium of remotest space are in unison with the hydrogen and sodium of earth.

In the phraseology of our mechanics we define matter and force as if they had an independent existence. But we have no conception of inert matter or of disembodied force. All we know of matter is its pressure and its motion. The old atom had only potential energy; the energy of its substitute, the molecule, is partly potential and partly kinetic. If it could be shown that all the phenomena displayed in the physical world were simply transmutations of the original energy existing in the molecules, physical science would be satisfied. Where physical science ends, natural philosophy, which is not wholly exploded from our vocabulary, begins. Natural philosophy can give no account of energy when disconnected with an ever-present Intelligence and Will. In Herschel's beautiful dialogue on atoms, after one of the speakers had explained all the wonderful exhibitions of Nature as the work of natural forces, Hermione replies: "Wonderful, indeed! Anyhow, they must have not only good memories but astonishing presence of mind, to be always ready to act, and always to act, without mistake, according to the primary laws of their being, in every complication that occurs." And elsewhere, "action, without will or effort, is to us, constituted as we are, unrealizable, unknowable, inconceivable." The monads of Leibnitz and the demons of Maxwell express in words the personality implied in every manifestation of force.

In this imperfect sketch of the increased resources, and the present attitude of the physical sciences, I have not aimed to speak as an advocate, much less to sit as a judge. The great problem of the day is, how to subject all physical phenomena to dynamical laws. With all the experimental devices and all the mathematical appliances of this generation, the human mind has been baffled in its attempts to construct a universal science of physics. But nothing will discourage it. When foiled in one direction, it will attack in another. Science is not destructive, but progressive. While its theories change, the facts remain. Its generalizations are widening and deepening from age to age. We may extend to all the theories of physical science the remark of Grote, which Challis quotes in favor of his own: "Its fruitfulness is its correctibility." Instead of being disheartened by difficulties, the true man of science will congratulate himself in the words of Vauvenargues, that he lives in a world fertile in obstacles. Immortality would be no boon if there were not something left to discover as well as to love. Fortunate, thought Fontenelle, was Newton, beyond all other men, in having a whole fresh universe before him, waiting for an explanation. But science wants no Alexanders weeping because there are not other worlds to conquer. For every heroic Columbus who launches forth, in however frail a bark, upon untried oceans, seeing before him rich continents where others behold only a wilderness of waters, there are precious discoveries in reserve. Surely the time has not yet come when the men in any section in this Association can fold their arms and say, "It is finished." Unless our physicists are contented to lag behind and gather up the crumbs which fall from the rich laboratories and studies of Europe, they must unite to delicate manipulation the power of mathematical analysis. Mathematics wins victories where experiment has been beaten. With good reason we applaud the many brilliant successes of instrumental research. Mathematical analysis, with its multitudinous adaptations, is the only key which will fit the most intricate wards in the treasury of science. With the help of her mathematical physicists, Great Britain has now taken a position in science which she has not held before since the days of Newton. In Germany, the physicists do not hold back from the most difficult problems of the day, because they are led along by experiment on one arm and by mathematics on the other. The zeal of the Italian scientists prevails over even the terrors of Vesuvius, and makes them ready to become martyrs, like Pliny the Elder, to Nature and humanity. France, too, out of the very ashes of her humiliation, sends an inspiring word to us. Since her defeat, her scientific spirit has been aroused as it was after the days of the first Revolution. Her Association for the Advancement of Science is only a two-year-old infant; but it has sprung into existence, like Minerva from the head of Jupiter, full grown and equipped. Already it has displayed a vitality and a prosperity which this Association, in its opening manhood, has not yet acquired. The words of its first president are as true for the United States as for France—that the strength and glory of a country are not in its arms, but in its science.

REASON AGAINST ROUTINE IN THE TEACHING OF LANGUAGE.

FROM THE FRENCH OF CLAUDE MARCEL.

Part I.—*What Reason prescribes.*

Two Different Classes of Languages.—The mode of teaching living and dead languages is nearly the same. The differences between these two classes of languages, and the ends sought in studying them, need to be better defined.

Living languages, like the mother-tongue, are simple instruments which cannot be too soon mastered for instruction in our own social relations, and information of the political, scientific, and industrial life of other people. But dead languages are not the depositories of science, nor do they serve for the exchange of ideas; they are studied solely for the intellectual development they favor.

A professor of Greek or Latin, who knows to its foundations the language of his pupils, in teaching the ancient language, can give them critical and rational instruction—can call into exercise their highest faculties. But a foreigner, teaching his own language, rarely learns the niceties of the French, and seldom knows it as well as his pupils. He cannot, therefore, in any way, use their own language to aid them in learning his; so he only attempts to give them a practical knowledge of it. Hence the methods of studying these two classes of languages should differ essentially. Exercises in the ancient languages should be a gymnastic of the mind resulting from their comparison with the national idiom; each lesson in Latin being also a lesson in French. Exercises in modern languages should be vehicles of thought without the intervention of the national idiom, and they should be so familiar as to become, through reading and hearing, sources of natural instruction.

The complete knowledge of a language includes four distinct arts—reading, hearing, speaking, writing. In an ancient language we need only the first of these arts. Its study should have no aim but that of giving the pupils the ability to read the classical authors, and appreciate the charm of their compositions. It is in meditating on the thoughts of the great writers of antiquity, and in translating their masterpieces, that we discover their beauties, and are able to transfer them into our native language.

In living languages these four arts should be the object of study. To say that one class of languages is learned to be spoken, and the other class to be read, does not express the exact difference of aim in the two cases. The art of speaking is useless unless we understand what is said, and this talent of understanding is a hundred times more useful than that of speaking. The same is also true of reading, for we rarely have occasion to speak foreign languages, while we may read them daily with profit. In reading, as in listening, we always learn something, and especially the language. In speaking we learn nothing, not even the language; the mind is not enriched with a word or an idea. The habit of following, in reading and hearing, the logical connection of ideas which characterizes serious discourse, forms the mind to all modes of reasoning, to all kinds of argument. But the habit of speaking, to the exclusion of listening and reading, implies a loss of judgment. The least instructed are often those who talk the most. It was not by speaking French, but by reading it, that the Prussians learned what they needed to know to insure their success against us.

It is infinitely more useful to read modern than ancient languages. The latter are seldom read after the period of school; but we read the former throughout life, not only for the intellectual pleasure they afford, but to gather knowledge needed in the professions and in our social relations.

Order of Study for a Living Language.—The child learns successively the four arts of his language. He first seizes the phraseology that interprets to him the language of action which accompanies the first words addressed to him. Gestures, expressions of the face, tones of the voice, are equivalent to phrases, not to words. So he understands the sense of phrases long before the words that form them. By the aid of these natural signs the infant listens and understands, then he imitates and speaks. It is only when articulate sounds awaken in his young intelligence the ideas of which they are the signs, that he seeks to reproduce them as he heard them. He owes his progress to example, not to precept; to practice, not to theory. Such is the method of Nature, admirable in simplicity and infallible in results. The nearer we come to it the surer will be our success.

Articulate and written words, the signs of ideas, being conventional, we can apply them justly only so far as we have received the impression associated with the ideas they represent, only so far as they are made familiar by the habit of reading and listening. In other words, the double talent of understanding the written and spoken foreign language conduces respectively to the arts of writing and speaking. Just as in learning our native tongue, it is by the judicious exercise of imitation founded on this double talent that we easily acquire the arts of speaking and writing. On this point the laws of our constitution and the nature of language are profoundly in accord.

In fact, we possess, as means of improvement, two powerful instincts, *curiosity* and *imitation*, which urge us ever toward the end Providence has assigned, and assure our success in the acquisition of language. Curiosity is the source of progress in the arts of reading and listening; imitation, which comes after curiosity, is the source of progress in the arts of speaking and writing. The duty of the professor is wisely to stimulate and direct these admirable instincts of his pupils.

In order, then, to conform to the rules of Nature, we should commence the study of a foreign language by reading and listening, which enriches the mind with ideas and knowledge, and at the same time puts it in possession of the corresponding phraseology. At the Lyceum this plan is reversed. Without regarding this innate desire to know, to gather ideas, we occupy the young with words by prematurely directing their attention to the arts of speaking and writing. The mind is not nourished, it is hindered, and in its turn it refuses that which is imposed upon it; or it is enfeebled under an irksome and unproductive labor. If so many young people are indolent and unwilling to study, it is because they are weighed down with lessons and duties repugnant to them: we distort Nature, and do violence to their instincts.

The art of reading a foreign language should be the first in the order of study, as it is the basis on which acquisition of the other three reposes. Besides being easier, more accessible, and attainable without a master, it surpasses them all in the number and importance of the advantages it presents. We derive the greatest benefit from it in the ordinary circumstances of life. We can practise it in all times and places, at home or abroad, whether for profit or pleasure, and so never forget it. It furnishes the means of studying the phraseology and deducing the laws of language, and only by means of it are we made acquainted with the doings of other nations.

The art of listening is the second in importance; it is the best part of conversation. Like reading, it satisfies the instinctive love of knowledge. If we perfectly understand what is said to us, a few words, a monosyllable, suffices to sustain conversation. This art demands a special exercise all the more, as listening is the true and only means of acquiring pronunciation. The vocal power is entirely under the government of the ear. At the Lyceum, not an hour is given to this exercise in all the course of study. How few persons, after four or five years of English in class, can understand Englishmen when speaking their language, and how few can pronounce English correctly!

In the vernacular, we pass from hearing to reading. It is spoken language, the first manifestation of our thought, which gives us the key to written language. In the same way, but in an inverse order, those who learn a language in books should often hear the written text, to familiarize themselves with the pronunciation and to recognize the written words in the spoken words. Their progress in understanding the spoken language will be much more rapid, if they comprehend the written language without translating it.

Reading is *direct* or *indirect*. In direct reading, the written expression recalls the thought, as in reading our mother-tongue. In indirect reading we arrive at the idea by the aid of the mother-tongue, that is, by translation. To read a foreign language directly is to think in that language: translation is thinking in our own.

When we have, for a long time, seen in books and heard in the talk of the master words associated directly with the ideas they represent, we have no difficulty in reproducing the orthography and pronunciation, the first elements of writing and speaking. The phraseology thus insensibly engraved upon the mind by repetition becomes one with the thought.

However, inconceivable as it seems, it is insisted that the principal object of studying a living language is, to be able to speak it. From this popular error, from this false point of departure, proceed almost all the methods in vogue. They aim, for the most part, exclusively at the acquisition of this art. Despising the order and the wise slowness of Nature, they break the chain which binds together the great purposes of language, neglect direct reading—the inexhaustible source of instruction and intellectual enjoyment—and listening—the most useful part of conversation—and of necessity resort to processes little in harmony with our organization and the nature of language.

Grammar, exercises, reading aloud, and mnemonic lessons, mere word-practice—the sole resource in teaching to write and speak a foreign language—do not help in the least in learning to read and understand it, nor even in learning to speak and write it, for lack of imitation, by which means alone these arts are acquired. This, it is true, is no great evil, for, out of a hundred people who learn to speak and write, there are not two, perhaps, who ever have serious occasion to use their knowledge. But what pains for nothing! what a loss of time!

Processes and Results.—The art of reading English, for example, is acquired rapidly, without groping, and without error, by taking for the first lessons familiar subjects treated in simple language, as free as possible from idioms, but strictly conformed to usage and to grammar; the French text, equally free from idioms, being placed on the opposite page. The triviality of the language in the first books is, in the end, no hindrance to progress. The best writers, the greatest orators, have begun with puerilities and commonplaces in learning their own language, and it will be the same in another if we assiduously read good authors.

Based on the truth that a student can translate only what he understands, the interpretation on the opposite page presents to him the thought of the foreign text: he passes, phrase by phrase, from the interpretation to the text, that is, from the known idea to the unknown words. Without pronouncing, he reads the French on the English—attaches to each English word the corresponding French word. In accordance with reason, he proceeds from the phrase to the words, from the idea to the sign. This translation is preferable to the use of a dictionary, because it faithfully renders the thought of the author.

It plays the same part as the language of action in the mother-tongue. In thus conforming to the law of Nature, by which we pass from the whole to its parts, this process saves the student from uncertainty and *ennui* in the understanding of authors, and he will naturally use it in reading outside of his lessons. The promptitude with which the pupil, by this method, seizes the thought of the author, gives an interest to the reading which cannot be attained when the attention is arrested on each word, and all connection of ideas destroyed by the use of a dictionary. Besides, in this way the pupil reads more in a given time, the same expressions recur oftener, and so are engraved upon the memory. Progress in reading is in inverse ratio to the time taken. For example, 100 pages translated at the rate of ten pages a day advances the student more in the art of reading than the same 100 pages read at the rate of one page a day.

My first reading-books of English are formed on this plan. Composed of anecdotes and familiar recitals that pique the curiosity, they are, so to speak, *practical vocabularies*, of which all the words have a determined meaning; they address the understanding as well as the memory. The reading again and again of the same passages impresses the words, with their terminations, upon the mind with more certainty than the mechanical learning by heart in grammars, vocabularies, and phrase-books, of the current methods.

Led by the interest of the subject, each sentence awakens a desire to understand the next, and to pursue the reading, while nothing is more fatiguing and discouraging than the work of reading disconnected phrases. The student will have only to read a few volumes with the translation on the opposite page, before he can translate good authors without this auxiliary. After this, the sense of the new words he encounters will be easily discovered from the context, or by the aid of the dictionary, and he will soon read the authors directly. From this moment he will progress in all the other parts of the study.

To free himself entirely from the translation, the student must read the same passages many times: he then seizes the sense more rapidly, and ideas associate themselves naturally with words. He must, above all, read the entire work. In proportion as he advances in reading a book, it becomes easier, while the same subject, the same style, remaining longer under the attention, the phraseology of the author will be more profoundly impressed on the mind, and will be more closely linked to the thought. The stories of which the first books of this method are composed belong to common language, and contain the words and phrases ordinarily employed, so that they familiarize the student with the most useful elements of conversation and correspondence.

The facility with which a pupil reads and the rapidity of his progress permit him to read more in three months than in three years by other methods. Those who object to this facility of work, condemn Nature; for the learning of the mother-tongue is so easy that it is acquired without any hesitation. Besides, this rapid progress leaves the student time for other studies.

Pupils who study alone are limited to written language, but with a master the spoken language may be entered upon by means of exercises in listening. By attention to the reading of the master, the art of understanding foreign speech is acquired even more rapidly than the art of reading; because the elements of language being very limited, they are frequently revived, and the association of the pronunciation with the written word is easily made. In this way an adult would be able in a year or eighteen months, in his own country, without *ennui* or effort, to learn to understand the written or spoken language as perfectly as the foreigners themselves; but never in the same circumstances would he be able to speak it as they do.

Children, by this rational method, could early learn a living language, and be in full possession of these two arts, which would serve conjointly with the mother-tongue in their other studies. As to the arts of speaking and writing, they cannot hasten acquisition, and they will be forgotten long before there is occasion to use them. Direct reading, on the contrary, far from being forgotten, will become by practice a habit of the mind, and, when the pupils leave the Lyceum, their knowledge of English and German will be powerful auxiliaries in the other careers to which they are destined, and they will be able through life, by the aid of the periodic press and new publications, to keep acquainted with all that is published by neighboring people.

The little time and expense involved in learning to read a foreign language, by means of translations on the opposite page, as well as the facility with which it is done, will be sufficient motives to make it an object of the higher primary instruction. Peasants need neither to listen, to speak, nor to write a foreign language; reading alone suffices them. The reading aloud of the mother-tongue, taught to children in the primary schools, without stimulating the curiosity or developing the taste for reading, leaves them all their lives with intelligence as limited, and in an ignorance as profound, as if they could not read at all. Such varied and extended reading as this method proposes, creates a taste for reading, and a desire to understand, without which the art of reading is worthless.

THE INTERNATIONAL EXCHANGE OF THOUGHT.—The twofold talent of reading and understanding, the most important in international relations, may be acquired by the humblest; since the first can be learned without a master, and the second requires only the services of a reader for a few weeks. Their acquisition is so easy and so rapid, when their study is taken out of the grooves of routine, that a pupil would be able, without neglecting any of the usual studies, to learn and understand half a dozen languages in less time than it would take to learn to speak and write a single one easily and correctly. It is so difficult to speak a foreign language, that in most cases recourse to this art materially hinders international exchange of ideas.

The order of studies in our lyceums inverts the order I have recommended. The university imposes written exercises in composition for the living languages, from the lowest classes to the highest. Imagine a French officer, *strong* in this department, in the country of an enemy, whose language when spoken he cannot understand. In his impotence to gather useful intelligence, what can he do but deplore the false direction given to his studies, and curse the incomplete teaching of the college? The attention of the young should be particularly directed to the arts of reading and hearing, which, if universally diffused, would alone suffice for the international exchange of thought. People of different nations, each speaking or writing his own tongue, would understand each other. Their conversation or correspondence would be every way much more intimate and satisfactory, when each used his mother-tongue, with the native freedom and clearness that he could not attain in a foreign language. In this way would be secured the great *desideratum* of modern society—the means of international communication.

By endowing youth with the ability to understand a foreign language when spoken, those who travel could, on reaching a country, enjoy the society of the inhabitants, mix in the movements of science, listen to the lessons of celebrated masters, and, in completing their scientific education, establish useful relations for life.

If the art of listening, a necessity of modern times, should take root in the schools of all civilized countries, it would second wonderfully the high aspirations of humanity. Never, more than now, have people felt the need of solidarity and fraternity; the mind of the century presses toward union in congresses, and associations for the discussion of important social, scientific, and political questions.

Mental Culture.—It is known that ancient literature offers models of composition, which aid, when studied, in forming and purifying the taste; while at the same time it cultivates observation and reflection by the analysis of thoughts and facts relative to an order of things above the realities of sense. But I shall not cease to repeat that, to obtain these results, the authors must be read *directly*. This acquisition should be the object of the first period of study. In the second period, critical teaching of the literature of these languages, if combined with profound study of the national idiom, will aid powerfully in the development of the intelligence.

As a means of cultivating the higher faculties of the mind, direct reading of the solid works of great writers, ancient and modern, is of indisputable efficacy. It is, in fact, a true *logique practique*. But the art of reading by free translation presents inestimable advantages, which cannot be obtained from any other branch of instruction, nor from a language of which only the first elements are known. Being able to enter into the spirit of the foreign text, the student easily seizes the relation between thought and its expression, and the analysis of the expression, needed to render it into French, becomes an intellectual exercise, which brings to his knowledge the genius of two languages and two peoples. If he translates a good author, he forms the habit of expressing in French only just ideas. He rises to the height of the author by appropriating his thoughts: his own conceptions become more clear by the effort he makes to express them clearly. He thus forms a good style, in trying to reproduce in his translation the qualities of the original.

Independently of its special use in giving power of expression, translation is an indisputable source of progress in mental culture. Correct expression and correct thinking are one and the same. Great eloquence implies high intelligence. The act of mind by which a student assures himself of the exact sense of the foreign text, and the search for expressions which shall better render the thought of the author, are operations of high intellectual import. They aid him to express his meaning, to analyze it, and to state it neatly in his judgments and reasonings.

In the efforts of a translator to render the original clearly, precisely, and conformably to the genius of his language, he corrects, expands, condenses his phrases, examines them under the relations of style and meaning. He reflects, observes, compares, judges, chooses understandingly, weighs the import of terms and reasonings, and appeals to analogy, to his recollections, and his own experience. It is this necessity of a complex action of the mind which is the principal merit of classical and literary study.

Some modern languages, as English and German, are rich in works which rival those of antiquity in force, clearness, and grace of expression, while imparting much more by the positive knowledge they contain. They might profitably replace the classics, but they would have to be taught by the French; and then, on the other hand, pupils would have small chance of being able ever to understand and read them like the English and Germans.

It is clear that, for this intellectual gymnastic, the language must be read directly. By so much as one falls short of this, he cannot derive advantage from the reading. In the first exercises of translation, whether we pass from the phrase to the word by the way of reason, or from the word to the phrase by the way of routine, we can neither take in the full import of the text, nor enter into the spirit of the author. We should seek the promptest means to free ourselves from oral translation, which is best done by means of the translation on the opposite page.

Translation, as ordinarily practised, not as an exercise in French composition, but to construe the authors, violates the law of Nature, which requires that we pass from the phrase to the words. In our native tongue we know the precise sense of words only by the phrases in which they occur; taken separately, they have no determined meaning. A phrase cannot be translated unless it is comprehended, and, to secure this comprehension, we make the translation for the student by employing words to which he attaches no precise idea! How could the mind develop under such a muddle of a system?

THE ART OF SPEAKING A FOREIGN LANGUAGE IN PUBLIC SCHOOLS.—Not having determined in a precise manner the relative importance of the objects proposed in learning a language, the means are confounded with the end. To persevere a long time in translation, whether to understand the language, to speak it, or to write it, is to form a habit which excludes the possibility of thinking in that language, and retaining the phraseology for use in conversation.

In the absence of classification, and of principles known to be in harmony with the constitution of man and the nature of language, the true objects of study are forgotten, and the order which facilitates acquisition is reversed. Pedagogy based on a knowledge of principles is unhappily a science little known, and generally ignored by teachers and professors.

The natural application of these principles to the acquisition of our native language offers us an infallible guide and simple processes of marvelous efficacy. By what perversity or blindness are we kept from the route traced for us by Nature? Why not avail ourselves of those powerful instincts, curiosity and imitation—especial sources of progress in the acquisition of language? Providence has given them to man to accomplish his destiny. It is an aberration of the human mind, it is almost an impiety, to reject them and seek other means for learning a second language.

Most authors of new methods make, it is true, the pretense of following Nature in their processes; but this is an illusion. Besides, they disagree among themselves, and consequently cannot all be true. Truth is ONE. There are not two ways of imitating Nature in attaining a particular end. All these methods and those of the university have this in common, that, in direct opposition to the laws of our organization, and the nature of language, they pretend to teach the speaking and writing of a foreign language, without depending upon reading and listening—without even making the least allusion to the necessity of thinking in that language. While public instruction perseveres in this false way, no young man will speak English or German on leaving college. He might be able, perhaps, in unconnected conversation, to pronounce some commonplace phrases, but he will not converse in the true meaning of the word.

The minister wishes that, after a little time, the classes should talk with their teacher in English and German; but what conversation can there be with professors, mostly foreigners, while the scholars are yet in the rudiments? The little they will have to say, which always relates to the lesson—a very limited subject—would never give sufficient practice to enable them really to speak the language. They find themselves together: the professor to give, the pupils to receive instruction. The teacher talks to them in a language they know perfectly well; they listen, and say nothing.

A general conversation outside the lesson would be less practicable. There is nothing in common between the professor and his pupils. There are no subjects, or they are always the same. But it is more than probable that, if, in the presence of thirty or forty pupils little versed in the foreign language, he should speak this language, and seek to make them speak it, all his efforts would produce only confusion, disobedience, and disorder. At best, this chit-chat could only take place in private instruction.

On the other hand, the difficulty of pupils in understanding the master, and the frequent correction of their errors, would constantly draw away the attention from the subject to discuss words; would discourage the pupils and fatigue the master, and make all genuine conversation impossible. But what time would thirty or forty pupils have to converse, in the three hours a week that is granted, even though they did nothing but converse all the time? Each one, if they took turns, would have *four minutes a week!*

The arts of speaking and writing are acquired without difficulty, if, conforming to the laws of Nature, pupils read and listen beforehand, and always associate the idea with the word. When they perfectly understand the spoken language, the professor can address his class in it, so that each lesson will be, for all, an advance toward the desired end. To listen, and understand what is said, is to learn to pronounce and to talk. Later, the book first used in reading and listening will teach, by imitation, the arts of speaking and writing. Recurring to example instead of rules, the pupils will take their phraseology as a model, and vary it infinitely in expressing their own thoughts.

EMOTIONS IN THE PRIMITIVE MAN.

By HERBERT SPENCER.

A MEASURE of evolution in living things is, the degree of correspondence between changes in the organism and coexistences and sequences in the environment. In the "Principles of Psychology," it was shown that mental development is "an adjustment of inner to outer relations that gradually extends in Space and Time, that becomes increasingly special and complex, and that has its elements ever more precisely coördinated and more completely integrated." Though in that place chiefly exemplified as the law of intellectual progress, this is equally the law of emotional progress. The emotions are compounded out of simple feelings, or rather out of the ideas of them; the higher emotions are compounded out of the lower emotions; and thus there is progressing integration. For the same reason there is progressing complexity: each larger consolidated aggregate of ideal feelings contains more varied, as well as more numerous, clusters of components. The extension of the correspondence in Space, too, though lest manifest, may still be asserted: witness the difference between the proprietary feeling in the savage, responding only to a few material objects adjacent to him—weapons, decorations, food, place of shelter, etc.—and the proprietary feeling in the civilized man, who owns land in Canada, shares in an Australian mine, Egyptian stock, and mortgage-bonds on an Indian railway. And, that the extension of the correspondence in Time may be asserted of the more evolved emotions will be manifest, on remembering how the sentiment of possession is gratified by acts of which the fruition can come only after many years, and even gets pleasure from an ideal power over bequeathed property; and on remembering how the sentiment of justice seeks satisfaction in reforms that are to benefit future generations.

As pointed out in a later division of the "Principles of Psychology," a more special measure of mental development is the degree of representativeness in the states of consciousness. Cognitions and feelings were both classified in the ascending order of presentative, presentative-representative, representative, and re-representative. This general order has been necessary; since there must have been presentation before representation, and representation before re-representation. It was shown, too, that this more special standard harmonizes with the more general standard; since increasing representativeness in the states of consciousness is shown by the more extensive integrations of ideas, by the greater definiteness with which they are represented, by the greater complexity of the integrated groups, as well as by the greater heterogeneity among their elements; and here it may be added that greater representativeness is also shown by the greater distances in space and time to which the representations extend.

There is a further measure which may be serviceably used along with the other two. As was shown in the "Principles of Psychology:"

> "Mental evolution, both intellectual and emotional, may be measured by the degree of remoteness from primitive reflex action. The formation of sudden, irreversible conclusions on the slenderest evidence is less distant from reflex action than is the formation of deliberate and modifiable conclusions after much evidence has been collected. And similarly, the quick passage of simple emotions into the particular kinds of conduct they prompt is less distant from reflex action than is the comparatively-hesitating passage of compound emotions into kinds of conduct determined by the joint instigation of their components."

Here, then, are our guides in studying the primitive man as an emotional being. Considering him as less evolved, we must expect to find him comparatively wanting in those most complex emotions that respond to multitudinous and remote probabilities and contingencies. His consciousness may be regarded as unlike that of the civilized man, by consisting in a greater degree of sensations and the simple represented feelings directly associated with them, and by containing fewer and weaker feelings involving representations of consequences beyond the proximate. And the relatively-simple emotional consciousness thus characterized we may expect to be consequently characterized by less of that coherence and continuity which results when the promptings of direct desires are checked by sentiments responding to ultimate effects, and by more of that irregularity which results when each desire as it arises discharges itself in action before counter-desires have been awakened.

On turning from these deductions to examine the facts with a view to induction, we meet difficulties like those which we met in the last chapter. As in size and structure the inferior races differ from one another enough to produce some indefiniteness in our conception of the primitive man—physical; so in their passions and sentiments the inferior races present contrasts sufficiently marked to obscure the essential traits of the primitive man—emotional.

This last difficulty, like the first, is indeed one that might have been anticipated. The spreading of the race during all past epochs into the multitudinous widely-contrasted habitats entailing widely-unlike modes of life has necessarily been accompanied by emotional specialization as well as by physical specialization. And beyond differentiations of character directly due to differences of natural circumstances and resulting habits, the inferior varieties of men have been made to differ by the degrees and durations of social discipline they have been subject to. Referring to such unlikenesses, Mr. Wallace remarks that " there is, in fact, almost as much difference between the various races of savage as of civilized peoples."

To conceive the primitive man, therefore, as he existed when social aggregation commenced, we must generalize as well as we can this entangled and partially-conflicting evidence: led mainly by the traits common to the very lowest, and finding what guidance we may in the *a priori* conclusions set down above.

The fundamental trait of impulsiveness, though one to be looked for as universal among inferior races, is not everywhere conspicuous. Taken in the mass, the aborigines of the New World seem impassive in comparison with those of the Old World: some of them, indeed, exceeding the civilized people of Europe in ability to control their emotions. Through stories most peoples have been made familiar with this trait of the North-American Indians; and the statements of recent travelers confirm those of older ones. The Dakotas are said to suffer with patience both physical and moral pains. The Creeks display "phlegmatic coldness and indifference." So, too, with various native peoples of South America. According to Burnand, the Guiana Indian, though "strong in his affections," will lose his dearest relations, as he bears excruciating pains, with "apparent stoical insensibility;" and Humboldt speaks of his "resignation." So, too, of the Uaupes: Wallace comments on "the apathy of the Indian, who scarcely ever exhibits any feelings of regret on parting or of pleasure on his return." And, that a character of this kind was wide-spread, seems implied by testimonies respecting the ancient semi-civilized peoples of America, who were not impulsive. Nevertheless, there are among these races traits of a contrary kind, more congruous with those of the uncivilized races generally. Spite of their usually unimpassioned behavior, the Dakotas rise into frightful states of bloody fury when killing buffaloes; and among the phlegmatic Creeks there are "very frequent suicides caused by trifling disappointments." Some of these American indigenes, too, do not show this apathy: as, in the North, the Snake Indian, who is said to be "a mere child, irritated by, and pleased with, a trifle;" and as, in the South, the Tupis, of whom it is said that "if a savage struck a foot against a stone, he raged over it, and bit it like a dog." This exceptional non-impulsiveness in many American races may possibly be due to constitutional inertness. Among ourselves, there are people whose habitual equanimity results from want of vitality: being but half-alive, the emotions produced in them by irritations have less than the usual intensities. That a general apathy, thus caused, may account for this peculiarity, seems in South America implied by the alleged sexual coldness.

Recognizing such anomaly as there may be in these facts, we find throughout the rest of the world a general congruity. Passing from North America to Asia, we come to the Kamtchadales, of whom we read that they are "excitable, not to say (for men) hysterical. A light matter set them mad, or made them commit suicide;" and we come to the Kirghiz, who are said to be "fickle and uncertain." Turning to Southern Asiatics, we find Burton asserting of the Bedouin that he is "a mixture of worldly cunning and great simplicity," and that his valor is "fitful and uncertain." And while, of the Arabs, Denham remarks that "their common conversational intercourse appears to be a continual strife and quarrel," Palgrave says they will "chaffer half a day about a penny, while they will throw away the worth of pounds on the first asker." Among the African races we find like traits. Captain Burton, saying that the East-African is, "like all other barbarians, a strange mixture of good and evil," describes him thus:

"He is at once very good-tempered and hard-hearted, combative and cautious; kind at one moment, cruel, pitiless, and violent, at another; sociable and unaffectionate; superstitious and grossly irreverent; brave and cowardly, servile and oppressive; obstinate, yet fickle and fond of changes; with points of honor, but without a trace of honesty in word or deed; a lover of life, though addicted to suicide; covetous and parsimonious, yet thoughtless and improvident."

With the exception of the Bechuanas, of whom even temper and self-command are asserted, the like is true of the races farther south. Thus, in the Damara, Galton says the feeling of revenge is very transient—"gives way to admiration of the oppressor." Burchell describes the Hottentots as passing from extreme laziness to extreme eagerness for action. And the emotional nature of the Bushmen is summed up by Arbrousset as quick, generous, headstrong, vindictive —very noisy quarrels are of daily occurrence: "Father and son will attempt to kill each other." Among the scattered societies of the Eastern Archipelago, those formed of Malays, or in which the Malay blood predominates, do not exhibit this trait. The Malagasy are said to have "passions never violently excited"—are not quick in resenting injuries, but cherish the desire for revenge; and the pure Malay is described as not demonstrative. The rest, however, have the ordinary trait. Among the Negrittos, the Papuan is "impetuous, excitable, noisy;" the Feejeeans have "emotions easily roused but transient," and "are extremely changeable in their disposition;" the Andamanese "are all frightfully passionate and revengeful;" and we are told of the Tasmanians that, "like all savages, they quickly change from smiles to tears." Among other of the lowest races there are the Fuegians, who "have hasty tempers," and "are loud and furious talkers;" and the Australians, whose impulsiveness Stuart implies by saying that the "angry Australian *jin* exceeds the European scold," and that a man "remarkable for haughtiness and reserve sobbed long when his nephew was taken from him." Bearing in mind that such non-impulsiveness as is shown by the Malays occurs in a race that has reached a considerable degree of civilization, and that the lowest races, as the Andamanese, Tasmanians, Fuegians, Australians, betray impulsiveness in a very decided manner, we may safely assert it to be a trait of primitive man, possessed, probably, in a greater degree than is implied by the above quotations. What the earliest character was, we may best conceive by reading the following vivid description of a Bushman. Asserting his simian appearance, Lichtenstein continues:

"What gives the more verity to such a comparison was the vivacity of his eyes, and the flexibility of his eyebrows, which he worked up and down with every change of countenance. Even his nostrils and the corners of his mouth, nay, his very ears, moved involuntarily, expressing his hasty transitions from eager desire to watchful distrust. . . . When a piece of meat was given him, and half rising he stretched out a distrustful arm to take it, he snatched it hastily, and stuck it immediately into the fire, peering around with his little keen eyes, as if fearing that some one should take it away again: all this was done with such looks and gestures, that any one must have been ready to swear he had taken the example of them entirely from an ape."

Indirect evidence that early human nature differed from later human nature, by having this extreme emotional variability, is yielded us by the contrast between the child and the adult among ourselves. For, on the hypothesis of evolution, the civilized man, passing through phases representing phases passed through by the race, will, early in life, betray this impulsiveness which the early race had. The saying that the savage has the mind of a child with the passions of a man—or, as it would be more correctly put, has adult passions which act in a childish manner—thus possesses a deeper meaning than appears. There is a genetic relationship between the two natures, such that, allowing for differences of kind and degree in the emotions, we may regard the coördination of them in the child as fairly representing the coördination in the primitive man.

The more special emotional traits are in large part dependent on, and further illustrative of, this fundamental trait. This relative impulsiveness—this smaller departure from primitive reflex action, this lack of the re-representative emotions which hold the simpler ones in check—is accompanied by improvidence.

The Australians are described as "incapable of any thing like persevering labor the reward of which is in futurity." According to Kolben, the Hottentots are "the laziest people under the sun;" and we are told that with the Bushmen it is "always either a feast or a famine." Passing to the indigenes of India, it is said of the Todas that they are "indolent and slothful;" of the Bhils, that they have "a contempt and dislike to labor"—will half-starve rather than work; while of the Santals we read that they have not "the unconquerable laziness of the very old Hill-tribes." So, from Northern Asia, the Kirghiz may be taken as exemplifying idleness; and in America we have the fact that none of the aboriginal peoples, if uncoerced, show capacity for industry. In the North, cut off from his hunting-life, the Indian, capable of no other, decays and disappears; and in the South the tribes disciplined by the Jesuits lapsed into their original state, or a worse, when the stimuli and restraints ceased. All which facts are in part ascribable to inadequate consciousness of the future—feeble grasp of distant results. Where, as among the Sandwich-Islanders, and in some of the Malay societies, we find considerable industry, it goes along with such a social state as implies discipline throughout a long past—conditions have caused considerable divergence from the primitive nature. It is true that perseverance with a view to remote benefit occurs among savages. They bestow much time and pains on their weapons: six months to make as many arrows, immense patience in drilling holes through stones. But in these cases, beyond the fact that the benefits are simple, proximate, and conspicuous, it is to be observed that little muscular effort is required, and the activity is thrown on perceptive faculties which are constitutionally active.[1]

A trait which naturally goes along with inability so to conceive the future as to be influenced by the conception is a childish mirthfulness—merriment not sobered by thought of what is coming. Though sundry races of the New World, along with their general impassiveness, are little inclined to gayety, and though among the Malay races and the Dyaks gravity is a characteristic, yet generally it is otherwise. Of the New-Caledonians, Feejeeans, Tahitians, New-Zealanders, we read that they are always laughing and joking. Throughout Africa, too, the negro shows us everywhere this same trait; and of other races, in other lands, the various descriptions of various travelers are: "full of fun and merriment," "full of life and spirits," "merry and talkative," "skylarking in all ways," "boisterous gayety," "laughing immoderately at trifles." Even the Esquimaux, notwithstanding all their privations, are described as "a happy people." We have but to remember how greatly habitual anxiety about coming events moderates the flow of spirits—we have but to contrast the lively but improvident Irishman with the grave but provident Scot—to see that there is a relation between these traits in the uncivilized man. The relatively-impulsive nature, implying total absorption in a present pleasure, causes at the same time these excesses of gayety and this inattention to threatened evils.

Along with the trait of improvidence there goes, both as cause and consequence, an undeveloped proprietary sentiment. When thinking about the nature of the savage, we overlook the fact that he lacks the extended consciousness of individual possession, and that under his conditions it is impossible for him to have it. Established, as the sentiment can be, only by multitudinous experiences of the gratifications which possession brings, continued through successive generations, it cannot arise where the circumstances do not permit these experiences. Beyond the few rude appliances ministering to his bodily wants, the primitive man has nothing that he can accumulate—there is no sphere for an acquisitive tendency. Where he has grown into a pastoral life, there arises a possibility of benefits from increased possessions—he profits by multiplying his flocks. Still, while he remains nomadic, it is difficult to supply his flocks with unfailing food when they are large,

[1] It should be remarked as a qualifying fact, which has its physiological as well as its sociological interest, that the characters of men and women are in sundry cases described as unlike in power of application. Among the Bhils, while the men hate labor, many of the women are said to be industrious. Among the Kookies, too, the women are "quite as industrious and indefatigable as the Naga women:" the men of both tribes being lazy. Similarly in Africa. In Loango, though the men are inert, the women "give themselves up to" husbandry "with indefatigable ardor;" and our recent experiences on the Gold-Coast show that a like contrast holds there. The establishment of this difference seems to imply the limitation of heredity by sex.

and he has increased losses from enemies and wild animals; so that the benefits of accumulation are kept within narrow limits. Only as the agricultural state is reached, and only as the tenure of land passes from the tribal form, through the family form, to the individual form, is there a widening of the sphere for the proprietary sentiment.

So that the primitive man, distinguished by his improvidence, distinguished also by deficiency of that desire to own which checks improvidence, is, by his circumstances, debarred from the experiences which develop this desire and diminish the improvidence.

Let us turn now to those emotional traits which directly affect the formation of social groups. Varieties of mankind, as we now find them, are social in different degrees; and, further, they are distinguished by different degrees of independence—are here tolerant of restraint and here intolerant of it. Clearly, the proportions between these two characteristics must greatly affect the social union.

Describing the Mantras, indigenes of the Malay Peninsula, Père Bourien says: "Liberty seems to be to them a necessity of their very existence;" "every individual lives as if there were no other person in the world but himself;" they separate if they dispute. So, too, of the wild men in the interior of Borneo, "who do not associate with each other;" and whose children, when "old enough to shift for themselves, usually separate, neither one afterward thinking of the other." A nature of this kind manifestly precludes social development; and it shows its effects in the solitary families of the wood-Veddahs, or those of the Bushmen, whom Arbrousset describes as "independent and poor beyond measure, as if they had sworn to remain always free and without possessions." Of sundry races that remain in a low state, this trait is remarked; as in South America, among the Araucanians, "the Mapuché is impatient of contradiction, and brooks no command;" as, according to Bates, among the Indians of Brazil, who, tractable when quite young, begin to display "impatience of all restraint at puberty;" as among the Caribs, who were "impatient under the least infringement" of their independence. Sundry of the Hill-tribes of India, too, exhibit a kindred nature. The savage Bhils have "a natural spirit of independence;" the Bodo and Dhimal "resist injunctions injudiciously urged, with dogged obstinacy;" and the Lepchas "undergo great privations rather than submit to oppression." This impediment to social evolution we meet with again among some nomadic races. "A Bedouin," says Burckhardt, "will not submit to any command, but readily yields to persuasion;" and he is said by Palgrave to have "a high appreciation of national and personal liberty," and "a remarkable freedom from any thing like caste feeling in what concerns ruling families and dynasties." That this moral trait is injurious during early stages of social progress, is in some cases observed by travelers, as by Earl, who says of the New Guinea people that their "impatience of control" precludes organization. Not, indeed, that absence of independence will of itself cause an opposite result. The Kamtchadales, according to Grieve, exhibit "slavishness to people who use them hard," and "contempt of those who treat them with gentleness;" and Galton, describing the Damaras as having "no independence," says they "court slavery"—that "admiration and fear" are their only strong sentiments. A certain proportion between the feelings prompting obedience and prompting resistance seems required. The Malays, who have evolved into several semi-civilized societies, are said to be submissive to authority; and yet each is "sensitive to any interference with the personal liberty of himself or another." Clearly, however, be the cause of submission what it may—whether want of self-assertion, or fear, or awe of superiority, which, separately and together, in different proportions, favor subordination—a relatively-subordinate nature is everywhere shown by men composing social aggregates of considerable size. In such semi-civilized societies as tropical Africa contains, it is conspicuous; and it was manifest in the peoples who formed the extinct Oriental societies, as also in those who formed the extinct societies of the New World.

If, as among the Mantras above named, intolerance of restraint is joined with want of sociality, there is a double obstacle to social union: a cause of dispersion is not checked by a cause of aggregation. If, as among the Todas, a man will sit inactive for hours, "seeking no companionship," he is under less temptation to tolerate restrictions, han if solitude is unbearable. Clearly, the ferocious Feejeean, in whom, strange as it seems, "the sentiment of friendship is strongly developed," is impelled by this sentiment, as well as by his extreme loyalty, to continue in a society in which despotism based on cannibalism is absolutely without check.

When we average the evidence, first as presented by the very lowest men who group themselves socially to the smallest extent, and then as presented by more advanced men forming larger aggregates, we find warrant for saying that primitive men, who, before any arts of life were developed, necessarily lived on wild food, implying wide dispersion of small numbers, were, on the one hand, not much habituated to associated life, and were, on the other hand, habituated to that uncontrolled following of immediate desires which goes along with separateness. So that, while the attractive force was small, the repulsive force was great. Only as primitive men were impelled into greater gregariousness by local conditions which furthered the maintenance of many individuals in a small area, could there come that increase of sociality required to check unrestrained action. And here we see yet a further difficulty which stood in the way of social evolution at the outset.—*From the "Principles of Sociology," Part I.*

BIOLOGY FOR YOUNG BEGINNERS.[1]

By SARAH HACKETT STEVENSON.

UNDER the low eaves at the back of the house was a long, deep wooden trough for catching the rain that fell on the roof. This old trough was to me a never-failing source of wonder and delight during my childhood. The inside of it was all lined with a beautiful, green, velvety mould, and, when there had been no rain for some time, the water itself would turn a greenish color. We used to catch our little downy yellow ducks and put them in the trough to see them swim, and sometimes they would break off and eat the green mould with their curious shovel-bills. What this queer, green stuff was, and how it came there, was a great mystery to us children. Charley declared it came down in the rain just as the angle-worms that he used for fish-bait. I had to wait a long time to find some one to explain to me all about these simple things. No doubt I might have learned about them here at home, if I had tried hard enough; but it so happened that I found a great professor in London, who was teaching his students just what I wanted to know, and he explained so well what I had seen in the old water-trough, and many other curious things, that I have thought my young friends might like to hear about them also. I am sure I should have been very glad if I could have found any one to explain them to me when I was a child.

Probably you have no trough in which you can find this green mould, but there is plenty of it on old palings, stone-walls, and the trunks of trees. That which comes on the top of water, and makes it look green, is a little different from that which covers old wood and stones, and we shall speak of this difference by-and-by. In order to see what there is in this green, mouldy matter, and what it is made of, you must look at it through the microscope. The word *microscope* comes from two words which mean *little*, and *to view*, and so this instrument is used to magnify, or make larger, things which are too small to be seen with the naked eye. Under it the dust of the butterfly's wing looks as large as the feathers of a canary-bird. Each of you ought to have a microscope of your own to study the things we are going to talk about, or several of you might club together and buy one, and use it "turn about." I am sure you would never regret the investment.

If you carefully scrape off a little of this mould from the trees or fences and look at it through the microscope, you can see that it is made up of exceedingly small bladders or bags. You will find little sacs

[1] From "Boys and Girls in Biology," now in the press of D. Appleton & Co., by a pupil of Prof. Huxley. Written upon the basis of his lectures, and illustrated by Miss M. A. J. Macomish.

something like these in all the substances we are going to examine. They are called *cells*. Sometimes cells are quite colorless and clear or transparent, but here you see they are colored—some are green, some red, and others are red in the middle and green at the border. You will notice that this coloring is all inside the cell, and not in the wall or outside cover of the cell; and sometimes, though not often, you can see this coloring-matter is formed in little grains. Now I wish you to

Fig. 1.—Mould-Cell.

Fig. 2.—Green Mould-Cell.

Fig. 3.—Mould-Cell with Red Centre.

Fig. 4.—Red Centre and Green Border.

notice the size and shape of the cells. You will find that most of them are from $\frac{1}{3000}$ to $\frac{1}{2500}$ of an inch in size, and nearly all of them have a round shape. Let us see now how many different things we can find in these cells. First, there is the outside cover or sac; this sac seems to be filled with something that looks like jelly, or the white of an egg, and in this jelly you can see the green and the red colored grains, a little round, hard-looking body that looks like a kernel, and sometimes in the middle of the sac there is a thin, empty-looking space. We will begin at the outside and look at each of these things separately, and try to find out what they are. If you press some of the

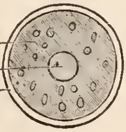


Fig. 5.

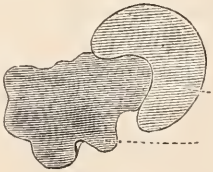


Fig. 6.—Broken Cell.

cells lightly they will burst, the soft inside part will flow out and leave the empty sac just the shape of the cell except where it is torn. This shows that the outside is much stronger and tougher than the inside. Chemists have found that this wall of the cell is made exactly the same as the tough cells of wood—it is called *cellulose.*

The light-colored jelly inside the sac has a long name of its own—*protoplasm*—which means *first form* or *mould*, because this seems to be the first form of all life. The green and the red colored grains are called *chlorophyll.* The word means *green leaf.* But *chlorophyll* is not always green: as you see in this mould, it is sometimes red, and it has many other colors; nor is it found in leaves only, as you will see when we come to study the stems and flowers of plants. But this dye-stuff or coloring-matter was first found in the leaves, hence its name—

green leaf. It is easy to remember; it will help you to think of the hard Greek name—*chlorophyll.*

The little round, hard kernel is called the *nucleus*, which means a nut or kernel, and the thin space in the centre is the *vacuole* or air-cell. It seems to be like a tiny drop of water separated from the rest of the jelly, which contains a good deal of water.

Now that we have described and named each of these different parts, we can go a step or even two steps farther, and tell of what the most of them are made, and of what use they are. The tough wall or sac of the cell is made of the woody matter or cellulose, mixed with a little water and mineral matter. The cellulose or woody part is made of three substances—*carbon*, *hydrogen*, and *oxygen*. If you ask me what these things are, I can only tell you that they belong to what are called the *simple chemical elements*, because each one is made of just one kind of matter. These three substances, and one other called *nitrogen*, help to make every thing there is in the world, except a few such things as gold, iron, sulphur, etc., which are also simple elements. The water is made of hydrogen and oxygen. Its use is probably to hold and protect all the inside parts, or contents of the cell. So much for the outside sac of the cell—now for the inside. The cell-jelly, or *protoplasm*, is made of water, fat, mineral matters, and *protein*. The water we already know. The fat is made of carbon, hydrogen, and oxygen. The minerals belong to the simple elements.

The *protein* we know but little about. We are sure that it contains carbon, hydrogen, oxygen, and nitrogen, with a little *sulphur* or *phosphorus*, or both, and we know that it is found in all living matter. There is no life without it, so it has been called the "basis of life." But there is a great deal more to be learned about it. I want you to remember what this word protein stands for, because it is something about this substance that makes one of the greatest differences between vegetables and animals. There is nothing in its appearance that would make you think it of so much importance; it looks to be nothing more than so much light-colored jelly, or white of egg. The word protein means *first* or *chief*, and this is the part of the protoplasm-jelly, which is alive. The kernel, or nucleus of the cell, seems to be only a part of the protein-jelly which is harder than the rest, and it has something to do with the making of new cells, as we shall see farther along in our study.

Now, what about the dye-stuff? Is it of any use, or is it just here to make the mould look pretty? It is of great use, as we shall soon see. Each grain is a very clever little chemist that works in the cell, which is his *laboratory*, or workshop. The sunlight is the fire by which this chemist heats his crucible, or melting-pot. Into this crucible he puts the poisonous gas, *carbonic acid*, that he gets from the air, and melts it up into *carbon* and *oxygen*, the two substances of which it is made. He keeps the carbon to feed upon, and gives back the pure oxygen to the air again. Thus he works from sunrise to sunset. His hours are regulated by the sun, instead of by Congress. You never hear of an "eight-hour movement" or a "strike" among the chlorophyil laborers. As soon as the sun goes down they go to bed, like honest workmen. During the night, while these green-leaf or chlorophyll workers are asleep, the colorless protein-jelly of the cell gives out the poisonous carbonic acid and takes in oxygen. The green cells give off carbonic acid and take in oxygen during the day, as well as during the night, but the little chlorophyll-grains do so much more work than the rest of the jelly in the cell, it seems as though the cell gives out nothing but oxygen and takes in nothing but carbon during the day, when all these little colored chemists are doing their best.[1]

Now you can understand why it is healthy to have growing plants in your room during the day, but not during the night. When the sun is shining they purify the air, because they give off more oxygen than carbonic acid; but at night they poison the air, because they give off only carbonic acid.

All plants that contain this green-leaf matter, or chlorophyll, are called green plants. You remember the colorless plants, such as toadstools, are called *fungi.* It is found, as you have seen, that green plants must have the sunshine, but fungi grow as well, or even better, in the dark. Thus we have found the materials out of which the mould-cell is made, and the use of all its different parts. Who would have thought there was so much to learn in one of those little bladders, when you first looked at it under the microscope! This green mould-plant has a very pretty name of its own—*protococcus.* The word means *first berry.* Perhaps this name was given because these cells look like little berries.

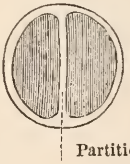


Fig. 7.—"Fission" of the Cell.

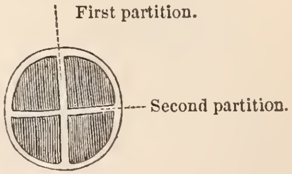


Fig. 8.—One Cell divided into Four.

If you look long and carefully, you can see the protococcus or berry-cell begin, like a little carpenter, to make a partition-wall right through the middle of the old house (Fig. 7); and, when the wall is finished, the two halves move away from each other, the carpenters

[1] Recent investigations seem to prove that the breathing of plants is similar to that of animals during both day and night; that the breaking up of carbonic acid is *digestion*, and not *respiration.* It has its seat in the chlorophyll, and is active in the sunlight; while the respiration, the breathing in of oxygen and the breathing out of carbonic acid, has its seat in the protoplasm, or protein of the cells. (*See* "Respiration of Plants," by Émile Alglave, Popular Science Monthly for November.)

round off the sides, and thus make two new houses out of the old one. Sometimes they build two partitions, as you see in Fig. 8, and, instead of two houses, there are four. What ingenious workers they are, thus to build four new houses out of one old one! They work so fast, too. The Chicago builders worked at the rate of a house an hour after the "great fire," but the protococcus builders can beat that, for they have been known to build one hundred thousand houses per minute, and that, too, in the winter-time, when the ground was all covered with snow!

The red protococcus, sometimes called "red snow," which is found in the arctic regions and among the Alps, will cover hundreds of acres of ground with its little red roofs in almost "less than no time." There are many curious stories told about this red snow. The ancients thought it was blood sprinkled down from heaven, as a warning of some great trouble, and it produced as much terror as comets and eclipses. But all the while it was only an innocent, pretty little plant. There is also a green protococcus that grows in the snow regions, and it is called the "green snow-plant." The red and the green snow-plants do not grow just in the same way as the protococcus of the trough or paling. The snow-carpenters divide their dwelling into a whole lot of little rooms (Fig. 9), then they "burst up" the old house entirely, and each one of the little rooms becomes a separate

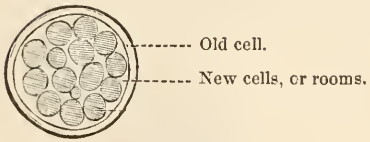


Fig. 9.—Snow-Carpenters dividing the Old House into New Rooms by Cleavage.

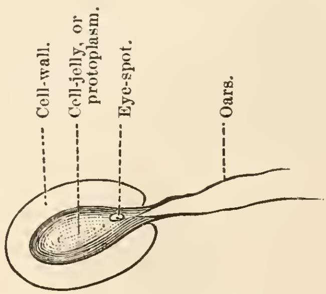


Fig. 10.—Boat, or Pear-shaped Cell.

mansion, and goes on doing the same thing for itself. This mode of building is called "cleavage;" the first kind is called "fission."

I told you there was a difference between the mould on the sides and the mould in the water of the old trough. You see that the protococcus mould you are looking at does not move about under the microscope, but remains quietly where you place it. Now, if you examine some of the protococcus that grows in old water, you will see the cells sculling about very fast, like so many little boats. If your eyes and microscope are very good, you can see the two tiny oars by which the little boatman guides his craft. There seem to be two kinds of boats —one small, green, and pear-shaped (Fig. 10); the others are larger, and look more like the carpenters' houses. The little pear-shaped boats often have a tiny red window, or port-hole, called the "eye-spot." If you watch long and carefully, you can see the little boatman pull in his oars (Fig. 12), as if to rest. But, if you shake the water, and then put it in the sun, out go the oars again, rowing faster than ever. The little pear-shaped cells do not have a tough, cellular sac; these independent little sailors seem to jump out of the boats

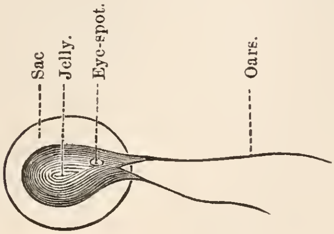


FIG. 11.—PROTOCOCCUS BOATS.

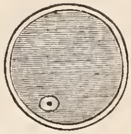


FIG. 12.—PROTOCOCCUS, OR BERRY-BOAT, WITH OARS PULLED IN.

entirely and swim about quite naked (Fig. 13). After they have bathed to their hearts' content, they seem to retire quietly to the sands and dress themselves again; that is, each one builds around himself a new wall, or boat, in which he rests till he needs another dip. The larger kind try to be more respectable; they stay in their boats in a dignified and proper manner. *Iodine* kills them, and then you can see where the little oars are pushed through the row-locks in the sides of the boat. These oars are called *cilia*—a word which

FIG. 13.—PEAR-SHAPED CELL WITHOUT A SAC, OR THE BOATMAN WITHOUT A BOAT.

means eyelashes. When the little sailors are getting tired, and just before they die, you can see these eyelash oars quite plainly, they move so slowly; but, when they are vigorous and the day is sunny, the oars move so fast you cannot see them. No Columbia or Cambridge crew can begin to pull with these protococcus boatmen. Besides being good oarsmen, they are also good builders. You may often see them breaking up the old boats by *cleavage* and *fission*, just as the carpenters break up the old houses.[1]

And so we have followed our quaint little friend, the protococcus, through all his occupations—chemist, carpenter, boatman, and ship-builder. Now, I am sure you will never again pass by an old fence, or a pool of green water, without thinking of the wonderful little arti-

[1] The kind of berry-moulds that grow on old wood and stones, and in the snow, is called *still protococcus*; that which grows in old water, and moves about by oars, is called *moving protococcus*.

sans that are working there. When I watched the ducks swimming in the old trough, little did I think of the noiseless hands that were building up those velvety-green walls, or of the unseen and unnumbered fleet of boats sculling through the water.

Young folks have a great fancy for "bloody stories;" so I am going to tell you not exactly a "bloody story," but a story about blood, and you need not be alarmed, for before I finish you will find there is nothing in blood to alarm any one, but a great deal that is useful, curious, and beautiful. If you prick your finger with a needle, and squeeze out a drop of blood and place it under the microscope, you will be astonished at what you see (Fig. 14). You can hardly believe that a drop of blood contains so many curiosities. First you observe a whole lot of little reddish-looking bodies, and among these a number of larger transparent bodies, which look like minute splashes of light-colored jelly. It is about these jelly-like bodies I am going to talk with you. If

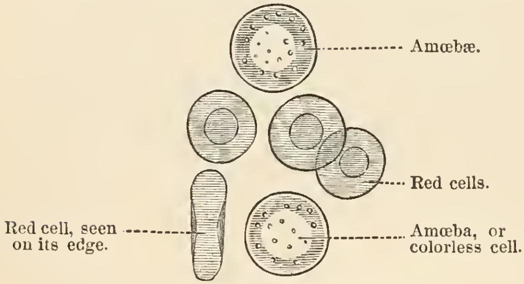


Fig. 14.—Blood-Cells, colored and colorless.

Figs. 15 and 16.—The Amœba or Blood-Cell changing its Form.

you keep your eye on one of them, you see that it continually changes its form, and that it has a slow, crawling kind of motion; and, if you try to make a drawing of it on paper, your picture will never be twice alike (Figs. 15, 16). It puts out something from one side which looks like a foot; then it draws in this foot, and puts out another at the other side, as if trying to find a soft place to walk upon. Sometimes it puts out several of these feet at one time. This little jelly-splash appears to use its feet as we use ours, to walk with, though you see it gets on quite slowly and awkwardly. Its foot is called a *pseudopodium*, which means *false foot.* These little bodies have a very suitable name—amœbæ, and the word means *changing.* This name was given to them, no doubt, because they are constantly changing their form. The amœba, or blood-cell, is larger than the still protococcus, or mould of the paling, and not quite as large as the moving protococcus, or green water-mould. It is usually about $\frac{1}{2500}$ of an inch in breadth. It does not possess the cellulose or woody sac, like the little protococcus houses. It is more like the pear-shaped protococcus boatmen. Its wall is just the hardened outer layer of the jelly or protoplasm. It has no thin space or vacuole, no "eye-spot," no eyelashes or cilia, and when it is quite fresh and new you cannot see any kernel or nucleus. You really can see nothing but an odd-looking lump, with here and there some little grains inside of it. If you give it a drop of weak vinegar or *acetic acid*, the little grains will disappear, and you can see the kernel in the centre (Figs. 18, 19).

You can find this kernel much easier if you stain the cell with *magenta* or weak iodine. Heat makes these amœbæ or blood-cells move

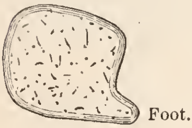


Fig. 17.

Figs. 18 and 19.—Cells cleared with Vinegar, so as to show the Nucleus.

much quicker, and it is very interesting to watch them make their way among the yellowish-red cells which lie in rows all around them. Sometimes one of the amœbæ will clear a channel for itself right through a thick group of the others. The first time I ever saw them moving in this way, I could not help thinking of the canals in Venice, where the gondoliers steer their gondolas close beside the houses, turning the corners so skillfully as never to strike them. So these little gondoliers of the blood went in and out, threading their way among the reddish-yellow cells, which stood in rows on either side the narrow channels (Fig. 20). There is one great difference, though: in Venice

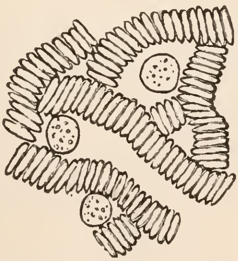


Fig. 20.—The Amœbæ pushing their Way among the Red Cells.

the gondolier has nothing to do but follow the canals that are made for him, but the amœba gondolier has to make his way as he goes. No wonder you open your eyes! It is enough to open any one's eyes to think of the thousands of these odd creatures that go half creeping, half walking through one's veins. You know people sometimes talk about their "blood crawling," but very few people know *how* the blood crawls.

If you heat the amœbæ they pull in all their little feet and become perfectly white and still, and nothing you can do will ever bring them back to life. These blood-cells that I have described are called "*human amœbæ*," or the amœbæ of man. Those that are found in the blood of other animals are somewhat different, but there is a kind of amœba, or crawling-cell, which grows on the top of stagnant water, that has a greater difference (Figs. 21, 22). Take a little of the scum that rises on ponds in hot weather, and put it under the microscope. In it you will find these jelly-lumps of a much larger size. They are from $\frac{1}{1000}$ to $\frac{1}{100}$ of an inch across, and move about by the same kind of queer-looking feet. But the border does not look at all the same. First, on the outside you see a clear, glassy-looking rim; inside of this is a thicker, darker ring filled with little grains—*granules.*

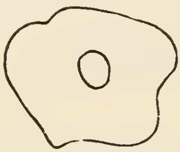


FIG. 21.—POND AMŒBA.

FIG. 22.—POND AMŒBA.

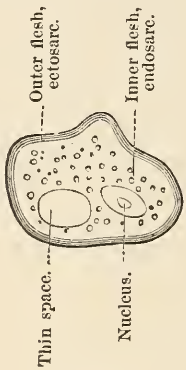


FIG. 23.

The centre of the cell is quite clear, and contains a thin space or vacuole, like that you saw in the yeast and green mould. The outer border or rim is called the *ectosarc*, which means outer flesh. The inner is called the *endosarc*, or inner flesh. Near the clear outer rim or ectosarc you will find the kernel or nucleus—a roundish, solid-looking little body which does not change its form. If you look closely you will see a small round, clear space in this outer rim or ectosarc which has motion, something like the beating of the heart. Indeed, by some it is thought to be the simplest form or beginning of a heart. It is called by a long name, the "*contractile vesicle*," or "*contractile space.*" All amœbæ do not have this heart, nor do they all have a kernel. This contractile space or heart is very important, because it seems to be doing a work of its own. This is the first time we have found one part of a cell doing something entirely different from another part. The jelly or protoplasm of the yeast and the green mould is "maid-of-all-work." But the amœbæ family seem to be looking up in the world, and are trying to pattern after those establishments that keep a servant for each kind of work.

Inside of some of these large pond amœbæ you will often find the green protococcus-cells, little *diatoms*, *desmids*, and all kinds of cells that are smaller than the amœba itself (Fig. 24). These it feeds upon, and, if you have patience to look long enough, you can see how it eats. It has no mouth in particular—the feet seem to taste of whatever comes in their way, and, if they like it, they grasp it, and poke it in anywhere into the middle of the jelly or protoplasm (Fig. 25).

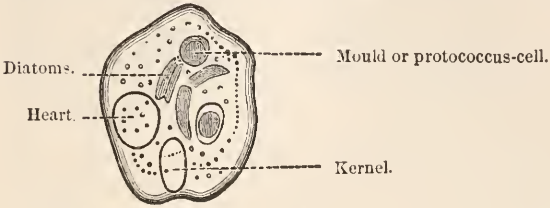


FIG. 24.—POND AMŒBA DIGESTING ITS FOOD.

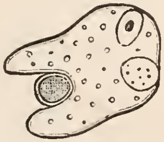


FIG. 25.—AMŒBA EATING.

Here it is digested, and all parts that cannot be used are pushed out again. All that the amœba has to do is to swallow the mass, suck out all the meat, and throw the rest away. There is one thing you must remember about the amœba; it must have its food or protein ready made. It has no power like the yeast or protococcus cell to make it for itself. So these little jelly-lumps we find in the blood and the ponds must be animals. You remember, I told you all vegetables make protein, while all animals eat it up. This little amœba animal gets its full share. He is a perfect little gourmand, taking in every thing that comes in his way. The human amœbæ are more fastidious in their taste. They do not swallow their food whole like the wild amœbæ. But those that are found in the blood of the newt or frog are regular little cannibals, and eat up their "colored brethren" whenever they get the chance.

Then, too, the feet or pseudopodia of the savage tribe are thicker and shorter than feet of the civilized kind. You see the toes of your amœba are quite dainty and tapering, like a lady's fingers. It is very curious to watch how a pseudopodium is made, especially of the pond amœba. First there is a little swelling or lifting up of the glassy

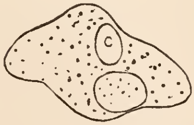


FIG. 26.—WILD AMŒBA.

FIG. 27.—HUMAN AMŒBA.

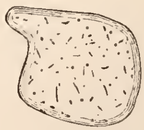


FIG. 28.—AMŒBA MAKING A FOOT.

rim or outer flesh (Fig. 28). As this swelling gets larger, some of the inner flesh flows into it, carrying the little grains, till the swelling is all filled up (Fig. 29).

Then the walking is so funny! The feet do not act as the feet of other animals, carrying the body above them. First, one stumpy foot is put out as far as it can reach, then the body all runs into the foot, and another foot is stuck out from some other part, and away goes the body into this new foot. So it gets on, the feet actually swallowing

Fig. 29.—Grains flowing into Foot.

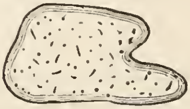


Fig. 30.—Trying to walk.

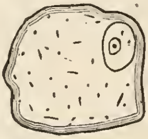
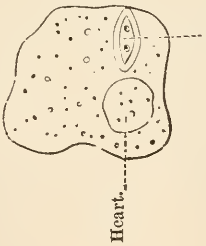


Fig. 31.—Stained with Magenta.

the body! The toad sometimes swallows its old skin, but the amœba is the only animal I know which is "taken in" by its feet! How odd it would be, if, as you walk along, you should suddenly disappear into your boots! If you crush the amœba, you find no trace of a tough sac such as you found in the yeast and protococcus cells. You can see nothing but the kernel or nucleus, and even that soon disappears. If you stain with magenta or iodine, the whole cell becoms colored alike. If there were a tough, woody sac, as in the yeast and mould, it would not be stained. The iodine does not give it a blue color, so there cannot be any starch in the amœbæ. The amœbæ grow like the green-mould cells, by fission, that is, by one or two partitions made through the old cells. You will first see two kernels appear in one of the old cells; then, by close watching, you see a partition going right down between the kernels, separating the old cell into two, with a kernel or

Fig. 32.



nucleus in each. Each new cell follows in the footsteps of its ancestors, crawling, eating, and growing, in the same way. And now I hope you have learned enough about this curious *amœbæ* family to put your wits to work and give us, some day, a full history of them, and tell us of what use they are, and what they mean by all their motions.

Boys, and girls too, sometimes, love to wade in ditches and ponds in warm weather. When you are thus wading, some time, if you will take up a piece of the duck-weed that grows on the surface of the water, you may see a number of slender green, brown, or orange-colored bodies, about a half-inch long, hanging down from the weed. If you shake or touch them the least bit, they get sulky and shrink

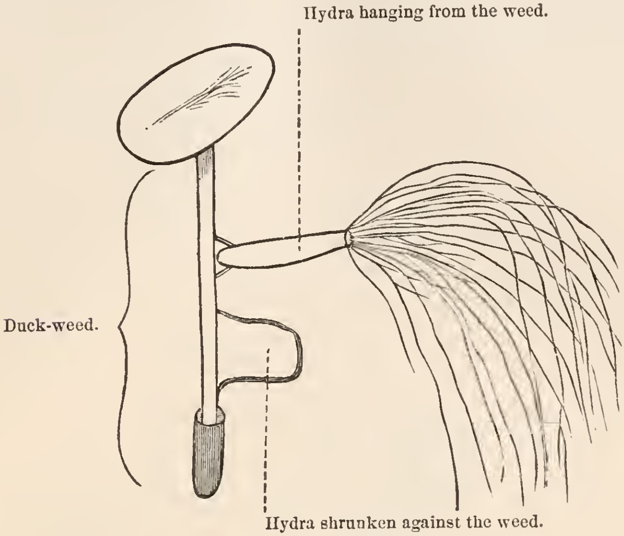


FIG. 33.

all up against the stem, looking like little pouting lumps of jelly. Place your bits of weed in a glass of water, and set the glass in the

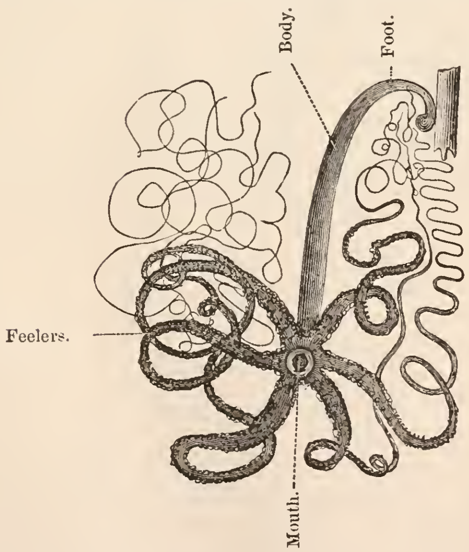


FIG. 34.—HYDRA FISHING FOR FOOD WITH ITS FEELERS OR TENTACLES.

light, but not in the sun, and in a few hours you will find a good many of these little creatures clinging to the side of the glass toward the window. They hold on to the glass by one end, and all around the other end, which is wider, are a number of long threads called *tentacles*, hanging down gracefully in the water. At first you might think them whiskers, as they grow out around the mouth, but *tentacle* means a *feeler* or *holder*, and with its *tentacles* you will see how our little friend feels and holds its food, and carries it to his mouth, almost as you use you fingers. These little animals are called hydræ, because if you cut them up each piece will grow again, as did the heads of the old Greek monster. If you look at your hydra under the microscope, you will find all these parts: first, there is the part by which it holds on; it is round and hollow, something like the bottom of a fly's foot, and it changes its size whenever the body of the hydra changes its form. When the hydra is stretched out full length, the foot is smaller than the body; but, when the hydra shrinks up against the glass, it

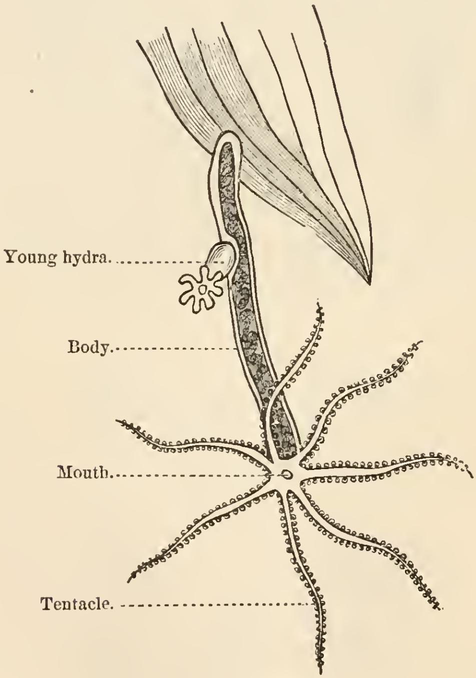


FIG. 35.—GREEN HYDRA.

seems to be all foot. When the body is stretched out, it is round and hollow like a pipe-stem, or more like a very slender funnel, and the opening at the large end surrounded by tentacles or feelers is the mouth.

The hydra's feelers are not all the same length; some of them are prettily colored, and all are filled with wavy knobs or knuckles along the sides (Fig. 35). The bag or body of the hydra is made of two coats. The outer coat is the *ectoderm* or "outer skin," the other is the *endoderm* or "inner skin" (Fig. 36). The cells in the outer skin of the *green hydra* contain those green grains or chlorophyll which give the green color. It is curious to see that the hydra makes its fingers, or tentacles, somewhat as the amœba makes its feet, or pseudopodiæ (Fig. 36). It pushes out its two coats in the same way, but it never allows its fingers to swallow it as the amœba is swallowed by

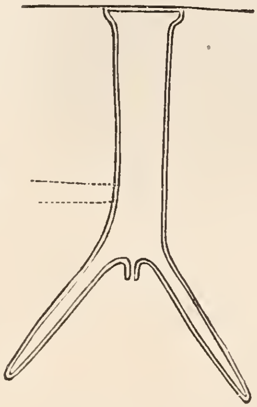


FIG. 36.—HYDRA PUSHING OUT ITS FINGERS.

its feet. When it is disturbed or frightened, it seems to swallow its fingers, or rather puts them all into its mouth, like a sulky child. It is a good deal higher up in the world than the amœba, for you remember that had to eat with its feet. Then, too, the hydra has a more aristocratic walk than the amœba. You can see it plant its foot firmly against the glass, then proudly bow its back and draw the rest of its body up to the foot, in the form of a loop, like the "looping caterpillar" (Fig. 37).

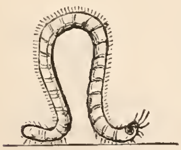


FIG. 37.—LOOPING CATERPILLAR.

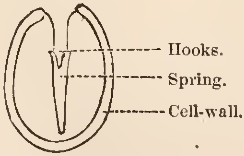


FIG. 38.—THREAD-CELL.

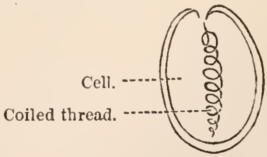


FIG. 39.—THREAD-CELL.

To be sure, it goes backward, but it is a great improvement on the walk of the amœba. It is also an excellent swimmer. You may often see it lift up its foot and dash into the water in search of food. It is one of the funniest things in the world to see the hydra catch its prey. I remember in my old geography a picture of Indians catching wild-horses with *lassos*. The lasso is a long rope with a loop at the end, which the Indian skillfully throws over the horse's head as he chases it over the prairies. So the hydra throws out his long, rope-like fingers, and lassoes the little animals that swim near it. Sometimes it gets hold of animals so strong that they may tear the fingers or tentacles, and get away again. But the hydra will not be outdone in this way. He has another weapon at hand. Some of the cells in the outer skin are oval, or egg-shaped, and if you look through the cell-walls you see inside what appears to be a long, coiled thread, with two hooks at the bottom (Figs. 38 and 39). These egg-shaped cells are called "*thread-cells*," and the hydra has many thousands of them in his feelers or tentacles. This thread or spring darts out of its shell whenever the hydra needs it, and sticks itself into the body of the prey like a sharp harpoon (Figs. 40 and 41).

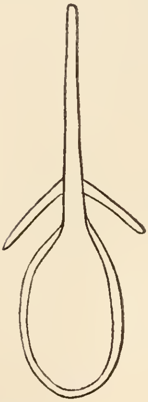


Fig. 40.—Thread-Cell, with its Thread uncoiled.

Fig. 41.—Thread-Cell, with the Spring turned out like a Harpoon.

If you examine this harpoon closely, you will find that it is only a part of the cell poked in like the finger of a glove turned inward; and when the fingers, or *tentacles*, seize an animal, these glove-finger cells that cover the *tentacles* all dart out. Some of them seem to contain a poisonous juice which stupefies or kills the prey in an instant. There is an animal in the sea called the *Portuguese man-of-war*, which is really a dangerous creature, it has so many of these sharp harpoons. When the prey is stunned or dead, the fingers carry it to the mouth, and it passes down into the long tube or body of the hydra, where it is digested, as though it were in a regular stomach. Along the outside of this funnel-shaped body you may often see little buds, which grow and give off other buds, till the old hydra looks like a branching tree. These buds, no doubt, make you think of something you have seen before—the yeast-babies—yes, these are the *baby-hydræ.* Soon their fingers begin to grow; then they loosen themselves from the old mother hydra, and begin to "fish for themselves." The next time you go wading, you must try and capture some of these

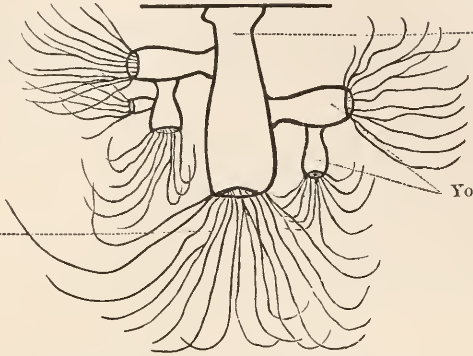


Fig. 42.—Old Hydra and Young Ones.

wonderful little creatures, and see if you can find all that I have described without my help. You are now, I trust, opening your eyes to the great world of living things all around you, in which you have lived and played, as I lived and played—*blindfolded.* And, when once your eyes are really open, wide, there is no telling what wonders they may behold.

SKETCH OF DR. JEFFRIES WYMAN.

By BURT G. WILDER,

PROFESSOR OF ZOOLOGY IN CORNELL UNIVERSITY.

WITHIN a year, science has lost two of her greatest leaders, Louis Agassiz and Jeffries Wyman. With the life, the works, and the appearance of the one, all are familiar. But the other was hardly known outside of strictly scientific circles. He rarely gave popular lectures, and never wrote any thing that attracted general attention. Yet his influence upon the progress of science in this country has been very great, and he had for years been regarded by all as the highest anatomical authority in America, and the compeer of Owen, Huxley, and Gegenbauer, in the Old World.

Jeffries Wyman was born at Chelmsford, near Lowell, Massachusetts, August 11, 1814. His father was a physician, as is his surviving brother. He was prepared for college at Phillips (Exeter) Academy, entered Harvard University in 1829, and was there graduated. During his last year in college he had an attack of pneumonia, which nearly proved fatal; this doubtless predisposed him to the pulmonary weakness from which he suffered during the latter part of his life, and from which he died on the 4th of September, 1874, at Bethlehem, New Hampshire.

Soon after his graduation he entered the Harvard Medical School, and, in 1836, became "house medical student" in the Massachusetts General Hospital.

In 1837 he received the degree of M. D. His graduation thesis was upon the eye, and accompanied by drawings. It does not appear to have been published, but, in September of the same year, the *Boston Medical and Surgical Journal* contained a paper by him upon the "Indistinctness of Images formed by Oblique Rays of Light." Soon afterward he became Demonstrator of Anatomy in the Medical School under Prof. J. C. Warren, whose chair he was destined afterward to fill.

In 1839 he accepted the curatorship of the newly-founded Lowell Institute. Two years later he delivered therein his first course of public lectures (of which no report has come under our notice), and with the money so earned went abroad for a year to pursue his medical and scientific studies under the great European masters. He had already, since 1838, published, in the *American Journal of Science*, several brief papers upon anatomical and physiological matters.

In 1843 there were published, in the *Journal of the Boston Society of Natural History*, anatomical descriptions of two gasteropod mollusks (*Tebennophorus Carolinensis* and *Glandina truncata*). Likewise a paper on the chimpanzee (*Troglodytes niger*), in which, with characteristic modesty, his account of its organization (though subversive of some of Owen's previous conclusions) is subordinated to Dr. Savage's remarks upon its habits and external characters. The same year he was appointed Professor of Anatomy in the Hampton-Sidney Medical College, at Richmond, Virginia. During his four years' stay his contributions to science included some notes upon fossil remains of vertebrates, and longer papers upon the blind fish of the Mammoth Cave and the teeth of the gar-pike (*Lepidosteus*). The latter paper is illustrated by microscopic sections, showing the close resemblance of the gar-pike's teeth to those of the fossil batrachian *Labyrinthodon*. The article closes with the suggestion that some of the separate teeth then referred by Owen to the latter genus might really belong to Lepidostean forms. This paper alone, though little known and never quoted by its author, would serve to show what manner of man was rising in America.

In 1847, at the age of thirty-three, he was chosen to the Hersey Professorship of Anatomy, at Cambridge. The year of his inauguration was signalized by his account of the gorilla, based upon specimens forwarded to him by Dr. Savage. This was the first scientific description of the new *Troglodytes.*

From that time forward his scientific progress was rapid and unbroken. He collected, he investigated, he lectured, he wrote. His admirable course of lectures upon Comparative Physiology, before the Lowell Institute, in 1849 (the report of which in pamphlet form has long been out of print), soon caused him to be regarded as the foremost among American anatomists and physiologists.

During this period, and indeed until within a few years of his death, Prof. Wyman published frequent brief notices of new animals, of points of structure and function, the value of which is in no way to be measured by their length. Almost any one of them would have served a less modest man for an extended memoir, while several contain the elements of interesting popular articles. So far from this, Prof. Wyman seemed to attach little personal importance to them, rarely referred to them, or took any pains to have them reproduced elsewhere. Many were, however, copied into European journals.

His first extended paper was "On the Nervous System of *Rana pipiens*" (the bull-frog). It covers fifty quarto pages, with two plates, was published by the Smithsonian Institution in 1853, and should be in the hands of every student of either human or comparative anatomy, as the clearest introduction to the most complex of animal structures.

Somewhat similar to the last, not quite so long, but even more replete with fact and philosophy, is the "Observations on the Development of *Raia batis*" (a skate), published by the American Academy of Arts and Sciences in 1864. This was based upon few materials, but sufficed to convince him, and all naturalists, that the skate ranks higher than the shark, since the latter retains through life a general form resembling one of the stages through which the former passes during its development.

Those who knew Wyman's nature may well imagine how he shrank from any thing like a discussion of two great questions upon which so much has been written during the past fifteen years, namely, the "Origin of Species" and "Spontaneous Generation." But, aside from his natural desire to know and teach the most correct doctrine upon these subjects, his prominent position made it imperative that he should consider them carefully. Respecting evolution, he evidently felt, with Prof. Gray, that, "upon very many questions, a truly wise man remains long in a state of neither belief nor unbelief; but your intellectually short-sighted people are apt to be preternaturally clear-sighted, and to find their way very quickly to one or the other side of every mooted question." In 1863 he wrote as follows: "We must either assume, on the one hand, that living organisms commenced their existence fully formed, and by processes not in accordance with the usual order of Nature, as it is revealed to human minds, or, on the other hand, that each species became such by progressive development or transmutation; that, as in the individual, so in the aggregate of races, the simple forms were not only the precursors, but the progenitors of the complex ones, and that thus the order of Nature, as commonly manifest in her works, was maintained."

No one can help seeing that he inclined toward belief in the general doctrine, but he neither indorses "Darwinism" nor denounces those who find themselves unable to accept "derivation" in any sense.

Regarding the appearance of organisms *de novo*, he never allowed himself to express a final opinion. He published two papers embodying the results of numerous and accurate experiments, and, we have reason to know, was still continuing his observations at the time of his death.

The general question to which Prof. Wyman gave most attention, until called from it by the Archæological Museum, was that of Organic Symmetry, especially as manifested in the limbs. Accepting the usual belief in an homology of the front and hind limbs, he associated therewith the idea first put forth by Oken, that the two ends of the body are symmetrical, or reversed repetitions of each other, as are the right and left sides. The application of this doctrine to the limbs makes the ulna the homologue of the tibia, the radius of the fibula, and the thumb of the *little-toe*, instead of the great-toe, as ordinarily believed.

So radically does this interpretation of "intermembral homologies" differ from that of most anatomists, that it is not strange that its acceptance is, at present, confined to a very few (Foltz, in France, and, in this country, Dana, Coues, Folsom, and the writer). But we are encouraged by the reflection that our leader never gave even a qualified assent to any doctrine which did not prove to be in the main correct.

Upon no other single problem did he bestow so much thought. And, as may be inferred, it is in his treatment of this question that his peculiar characteristics appear. In the adoption of new ideas he manifested a wise caution, which, contrasted with the haste of others less well informed, illustrates the maxim, "Fools rush in where angels fear to tread." We recall his freedom in discussion with his students and his kindness in aiding their advancement, even to his own apparent detriment; his modesty, occasioning a lack of reference to his own papers or to unpublished investigations; his critical acumen, which was the more searching and useful from its entire freedom from personality; and, finally, here shine forth in their greatest brilliancy those rare qualities which enabled him, when occasion required, to overlook the delusive charms of teleology, though upheld by popular interest and theological authority, and to regard her plainer but more reliable sister, morphology, supported by relative position and mode of development.

In 1866 Prof. Wyman was named one of the seven trustees of the Peabody Museum of American Archæology and Ethnology, and became curator. For this work he was peculiarly fitted, both by nature and by his extensive observations upon crania, and his frequent investigations of shell-heaps, etc., during the trips to Florida, which his health had of late years forced him to make. Our space will not permit even a brief sketch of his labors in this new field; the results are modestly recorded in his annual reports. At present, the Museum is very extensive and admirably arranged. Had Prof. Wyman been spared for another ten years, one can hardly predict its importance. Of this, and of his own anatomical collections, the value is wholly out of proportion to the size or actual cost in money, for they represent the constant and skillful labor of a great anatomist during a quarter of a century. The label upon every specimen tells the truth so far as he knew it; and in the descriptive catalogues are rich treasures of fact and thought as yet unrevealed.

Prof. Wyman always shrank from public notice, and from positions in which this was involved. He attended several meetings of the American Association for the Advancement of Science, and served therein as president, treasurer, and secretary. But his communications were few, and comparatively unimportant. He was a member of the American Academy of Arts and Sciences, and was named by Congress one of the original fifty members of the National Academy of Science, but soon resigned. In strong contrast with his slender relations with these organizations is his record in connection with the Boston Society of Natural History. He early became an ardent member, served as secretary, and as curator of several departments, and in 1856 became president. This office he held until 1870, when he offered an unqualified resignation.

Meagre as is the above account of his outer life, we shrink yet more from any such estimate of his abilities and his personal character as the present occasion will permit. Admired and trusted by his associates, by the younger naturalists he was absolutely adored. Ever ready with information, with counsel and encouragement, so far from assuming toward them the attitude of a superior, he on several occasions permitted his original observations to be more or less merged within their productions. The universal regard in which he was held by them is, in the writer's case, intensified by the sense of peculiar obligations, which might cloud his judgment of any ordinary man; but to no man more fitly than to Wyman could be addressed the lines:

> "None knew thee but to love thee,
> Nor named thee but to praise."

Nor was any criticism ever made upon him, from any quarter, other than upon his extraordinary freedom from personal ambition, and his aversion to public notice or display.

Wyman's anatomical work was absolutely free from zoological bias, and his statements were always received as gospel by both parties to a controversy. He might not tell the whole truth, for he might not see it at the time; but what he did tell was "nothing but the truth" so far as it went. The hottest partisan felt that a figure or description of Wyman's was, so far as it went, as trustworthy as Nature herself.

Without brilliancy, Dr. Wyman combined qualities rarely found in the same individual. No man of our time has surpassed him in the love of Nature for its own sake, free from the hope of position, power, or profit; in keenness of vision, both physical and mental; in absolute integrity, with the least as well as the greatest things; in industry and perseverance; and in method, whether for the arrangement of collections, or the presentation of an idea. And if to these had been adjoined a tithe of the ambition displayed by smaller men, and had his health and strength been at all equal to his mental powers, no one can doubt that his attainments, his productions, and his reputation, would have been surpassed by none of his contemporaries.

However much we may, for our own sakes, regret that such was not the case, we know that into his mind never entered the shadow of bitterness. His recognition of others' labors was full and generous; his mind was upon the facts and principles of Nature, and regarded not the medium through which they were obtained; and if he ever prayed for health and strength, it was surely not for his own advancement, but because he felt within himself the desire and the ability to learn and to teach the truth.

Dr. Wyman's reputation was less wide than that of some others; but it was deeply rooted. As the years roll on, and as the final estimate is made of the value of what has been done in this century, we may be sure that the name of Jeffries Wyman will stand high among those who have joined rare ability and unwearied industry with a pure and noble life. To use his own words upon a like occasion, "Let us cherish his memory and profit by his example."

EDITOR'S TABLE.

THE CONFLICT OF RELIGION AND SCIENCE.

IT is a common remark that there is no necessary hostility between religion and science; and this is unquestionably true. That they will be ultimately harmonized we cannot doubt; but the world is very far from having yet reached that blessed consummation. The scientist and the religionist can get on comfortably together as long as they talk in very general terms; but when they come to close quarters, and press earnestly for definitions, collision is pretty certain to ensue. This is partly due to the one-sidedness of the parties; much to still unresolved difficulties in the relation of the subjects; and not a little, it must be confessed, to that spirit of pugnacity by which humanity is still eminently animated. It is an age of propagandism and proselyting by tongue and pen; and the graceless multitude, moreover, always enjoys a good fight. The Archbishop of York was called to Edinburgh to lecture before the Philosophical Society, and the chance of pommeling some of our modern so-called philosophers was too good to be lost. Prof. Huxley happened to be engaged to give a lecture in the same town shortly after, invited by a religious body, and he would have been more a saint than his predecessor, if he could have refrained from giving back some of the archbishop's blows. In vindicating his school from the charge of materialism, Prof. Huxley felt it incumbent upon him to inquire into the nature of the juices of living things, and thus innocently kindled the great war of protoplasm that has stirred the combative propensities of the religious and scientific world to this day. And again, from the way the President of the British Association has been lately belabored by religious and semi-religious people of all sorts, we must conclude that the temper of antagonism is far from having yet died out, and that there must be a good deal more vigorous campaigning before a peace will be finally conquered.

Indeed, this conflict just now threatens to assume far larger proportions, and to be renewed upon a scale which we have been accustomed to consider as belonging to the distant past. The entire population of Europe is estimated at about 301,000,000, of which 185,000,000 are Roman Catholics, 71,000,000, Protestants, broken up into numerous sects, and the remainder are Greek Catholics, Jews, and Mohammedans. The adherents of the Roman Catholic Church are thus more numerous, by 69,000,000, than all sorts of religious people taken together. The Roman Church is the most extensive and powerfully organized of all modern societies, and with a mighty prestige of historic associations and traditions, claims to be supreme, infallible, to act under a divine commission, to have for its head the vicegerent of God, and to exact the most implicit obedience from all the members of its communion. It had long been believed that the Roman Church, silently yielding to the advance of intelligence and the growing spirit of liberality in modern times, has abated something of its ancient and arrogant pretensions; but there is not a little reason to think that this was an erroneous impression. In his "Encyclical Letter," put forth by the head of the Church, in 1864, the pope denounces that "most pernicious and insane opinion, that liberty of conscience and of worship is the right of every man, and that this right ought, in every well-governed state, to be proclaimed and asserted by law; and that the will of the people, manifested by public opinion (as it is called), or by other means, constitutes a supreme law, independent of all divine and human rights." It denounces "the impudence" of those who presume to subordinate the authority of the Apostolic See "conferred upon it by Christ our Lord, to the judgment of the civil authority." In 1868, Pius IX. issued a bull convoking an Œcumenical Council to meet at Rome, December 8, 1869, and its sessions lasted till July, 1870. The decrees of the Vatican Council, carried by 451 out of 601 votes, asserted the infallibility of the Roman pontiff, and defined the relations of religion to science. Many opinions were solemnly condemned, and their holders anathematized. Among others:

"Let him be anathema—

"Who shall say that human sciences ought to be pursued in such a spirit of freedom that one may be allowed to hold as true their assertions, even when opposed to revealed doctrine.

"Who shall say that it may at any time come to pass, in the progress of science, that the doctrines set forth by the Church must be taken in another sense than that in which the Church has ever received and yet receives them."

The gauntlet was thus thrown down by this august and powerful religious body to science, independent inquiry, and the whole spirit of modern civilization. The old conflict was revived with no narrowing of the issues. The Archbishop of Westminster, Dr. Manning, in his late inaugural address to the Roman Catholic Academia, referred to "the modern skepticism, free thought, and so-called scientific teachings of the day in relation to Catholic teaching; and, for an illustration of the style of thought, he would refer them to Prof. Tyndall's address the other day at the Belfast meeting of the British Association." He furthermore said: "Within the last twenty-four hours it had been intimated to him that the Catholic world was threatened with a controversy on the whole of the decrees of the Vatican Council. From this and other matters which had come to his knowledge, he could see that they were on the very eve of one of the mightiest controversies the religious world had ever seen. Certainly nothing like the controversy on which they were about to enter had occurred during the last three hundred years, and they must be prepared. If they would only prepare themselves, he did not fear for the decrees of the Vatican Council, or for the Vatican itself. But they must have no half-hearted measures." The expected stroke came in the shape of an able pamphlet from Mr. Gladstone, in which he asked of English Catholics what they are going to do about the demands of the Vatican Council in regard to their allegiance to the pope in matters of civil authority. The document of the English statesman has been extensively diffused, has made a profound sensation, and precipitated vehement discussion in all quarters.

But Mr. Gladstone has only touched the surface of the subject. He takes a politician's view of the influence and tactics of the Church; yet this is by no means its most important aspect. With the decline of the temporal power of Rome, spiritual control is substituted for secular control, and the pressure taken off of the state is put upon the individual. While Mr. Gladstone's imputation that Catholics are lacking in loyal allegiance to government is resented by the representatives of the Church with indignation, no question is raised as to the invincible purpose of the Roman power to resist the advance of free thought and the progress of liberal opinions. And this is immeasurably the most important aspect of the subject. The right of the pope to sit in judgment upon the civil power may be still asserted for consistency's sake; but, his right to coerce the individual conscience, to repress free investigation, to decide what is true and what is false, on the most momentous questions, and to take absolute control of the work of education, is maintained with earnest purpose and unabated rigor. It was to this task that the Vatican Council mainly addressed itself. The increasing spread of science was the ground of alarm, and against it the anathemas of the Council were chiefly hurled. With these relations of the subject Mr. Gladstone has not dealt, while, to deal with them broadly and thoroughly, requires a mind with a very different preparation from his.

The question is, first of all, an historic one. As the future must be determined by the tendencies of the present, and as these tendencies are the outcome of the past, he who would broadly comprehend the issues of today must turn back and study the contests and struggles of former generations through which the present state of things has been reached. The Catholic prelate of England says that we are on the "eve of one of the mightiest controversies the religious world has ever seen," but this cannot be an uncaused result; it is rather the natural and necessary sequence of "one of the mightiest controversies" which has been agitating the world for thousands of years. It is a controversy in which the elements of obstruction and of advancement have been in play upon an immense scale, which has drawn nations into its vortex, and issued in nothing less than the development of civilization itself. Nothing has been more wanted than a delineation of the causes, the course, and the consequences of this great struggle; and this desideratum is now supplied by the "History of the Conflict between Religion and Science," by Dr. John W. Draper.

The author of this work has won a world-wide reputation alike as a man of science and an historian, both qualities being required in an eminent degree for the performance of the task. Dr. Draper began his scientific studies in extreme youth, and they have taken a wide range. Both in the field of physics and in that of physiology he is a master, and his eminent position as an original investigator has been long conceded in all civilized countries. He has done his share in extending the boundaries of knowledge, and his acquaintance with science is therefore not at second-hand, but is thorough and trustworthy. Being of a philosophic cast of mind, he was early drawn to the consideration of science in its historic development. He thus passed to the study of history, and naturally took up its problems from the scientific point of view; that is, he read them in the light of an extensive familiarity with the laws of the natural world. His "History of the Intellectual Development of Europe" is a work of great learning and originality, which has been translated and republished in all the leading civilized countries of the world. That it has been highly appreciated by eminent men, need hardly be said. It was quoted, as we are all aware, by Prof. Tyndall, in his late address before the British *savants;* and when not long ago, in Berlin, the distinguished physiologist, Prof. Virchow, remarked to the present writer, "Give my compliments when you return to your eminent countryman Dr. Draper, and say to him that, when my son left home to pursue his studies, the only book I gave him was the 'History of the Intellectual Development of Europe.'"

Thus prepared, Dr. Draper has entered upon a chapter of history never before systematically undertaken. History in relation to science has hitherto been confined almost entirely to its subject-matter. Dr. Draper, on the other hand, considers the progress of science more in its human relations, or as connected with the interests and experiences of humanity. While others detach it from the accompanying circumstances, he views it as dependent upon them, as implicated with human passions and prejudices, and the influences of race, faith, nationality, states of society, and all the forces of obstruction and acceleration by which the human mind is affected. The most conspicuous and important feature in the history of science he considers to be its long conflict with theological authority. Religion was first in the field, and reigned supreme before science appeared. It put forth supernatural claims to the understanding of Nature, so that the profound ignorance of the natural world had a kind of religious consecration. To inquire was to question received explanations, to doubt pious beliefs, and was therefore impious. In its faint beginnings, therefore, among the pagan Greeks, science was denounced for the same reasons and in almost the same terms that it was recently anathematized by the Vatican Council. To fill in the links of the long-protracted struggle that has intervened, and delineate the stages of the mighty controversy which Dr. Manning declares to be now impending, was the object of Dr. Draper in preparing his work. He has, therefore, not only supplied an obvious want of historic literature, which would have been valuable at any time, but in the present crisis of the great elements, political, religious, and scientific, he has given us a text-book of the subject, by which the experience of the past is made the basis for an intelligent judgment of the present. The problem is undoubtedly immense—too great for any thing but proximate solution, and in a pioneer attempt we are not to expect perfection; but Dr. Draper has done his work ably and courageously, and in a manner worthy of his high reputation and the greatness of the theme. His book will be read with avidity by thousands in both hemispheres, who will gladly acknowledge their indebtedness to it for help and light in the present crisis of the questions it considers.

NORMAL CO-EDUCATION.

In the October Monthly we published a letter of Prof. Cochran, from Dr. Clarke's late work, "The Building of a Brain," on the effects of co-education in the Albany Normal School. We have received a suggestive letter from a lady who was connected with the institution at the time, and who says that "the cases of illness or of failing health among the young ladies were sent to me to inquire into and care for;" and she adds that, "to those familiar with the work of the Albany school, at this period, no statistics drawn from its health-roll would count any thing whatever in this discussion." It is mentioned that, "in 1864, when Prof. Cochran left Albany, in a school of over two hundred pupils, there were twenty gentlemen, so that, as far as education is concerned, it would seem that some deference might have been paid to the greatest good of the greatest number." The curriculum is, however, characterized as "oppressive." Our correspondent claims to have investigated the subject, and says that, while "with regard to the facts there is little question, with regard to the causes there is a very important one." Her general view of the case is presented in the following passages from her communication:

"I have reached the conclusion, from my investigations, that no statistics drawn from mixed schools can prove any thing with regard to co-education or identical education, until the two sexes can be placed in those schools upon equal or similar conditions.

"While there are a hundred outside things that militate against a woman's success in such a school, which find no parallel in the conditions of the male pupils, ill health or want of power among the female pupils can prove nothing. In every quarter woman is unfairly weighted for the race; but especially in our normal schools these conditions have reached their climax. For example:

"In 1856 one of the young ladies, whose

failing health warned her of overwork, came to me not more than two months before the time when she should have graduated. Hard as the case seemed, I could only say to her that she must leave school at once. Some facts of her history I obtained from her at that time, but the important points I learned later. She had no home to which she could go. She had been left an orphan at an early age, with a family of brothers and sisters dependent upon her for support. To meet this responsibility she went as a teacher into our district schools. She undertook the hardest positions because they gave a trifle more of pay. She boarded herself, and often went dinnerless to school because the children's bread must not be stinted. She went through mud and snow to her school, with wet feet and scanty clothing, purchasing no rubbers, no warm shawls, because she could not spare the money. She had soon decided that, if she ever lifted those she loved so well from utter poverty, she must fit herself for higher positions, and to this end she began laying aside money that she might attend a normal school.

"So the years passed on, and at last she had saved enough to take her through the two years' course of the normal school at Albany. And now when her classmates were beginning to think of their graduating essays and graduating dresses, her pay-roll was wound up, her summons came, and she turned away from the reward she had sought so tirelessly. The autumn leaves of 1866 fell upon the grave where she found rest for the first time in so many years. This is one of Prof. Cochran's twenty. Another, the same year, was accustomed to take an empty dinner-basket with her to school, and at the hour of lunch to steal away from her companions, that they might not suspect she was too poor to buy a dinner! In my own experience these have been not isolated but representative cases of normal-school invalidism. So familiar have I become with them, that I seem to know beforehand what items I shall obtain in investigating any given case of ill-health. And then the cry arises, 'Co-education does not answer.' It is true we have cases of ill-health among our young ladies which are not to be traced to these causes, but they are so few as hardly to deserve mention. These really make up the bulk of the cases with which we have to deal.

"We have also young gentlemen whose health fails from overwork, but to them the admonition arises in the shape of weak eyes, constant headaches, etc., while with women the more delicately-balanced functions of life are set ajar.

"The young man goes out to teach, and earns sixty dollars per month, while his sister is earning thirty dollars. In half the cases she is the better scholar. The young man goes home to the farm. He is needed in the field, but he is a man—of course he can earn one and a half or two dollars per day; while with his sister they are so glad she has come home to help mother, but it never occurs to any one that she has earned any money. When both return to school, they pay the same price for board, but with him it means that his bed shall be made, his room swept, water brought in, etc., while his washing arrives from the laundry all right every week. But she—the landlady says, 'Of course you will take care of your own room, we always expect our lady-boarders to do that.' She counts over her thirty dollars per month, and says, 'Well, I must do my own washing and ironing if my landlady will allow me.' And the landlady grudgingly consents. Then—'I must make my own calico dresses—I could never afford to pay for that.' To her teacher: 'I wish I could be excused from singing, to-day, I am trying to make a dress.' Or, 'No, I cannot go for a walk, my brother has brought me this whole satchel full of clothes to mend.' In the morning he can easily learn his algebra-lesson while she is arranging on the top of her head the steeple of braids which custom says she must wear. And so the parallel runs on."

From all which, it would seem to be a fair inference that, as the world is at present constituted, co-education is beset with very formidable difficulties. With their inferior strength, their extra burdens, and their more limited pecuniary means, the female students cannot compete with the male students, and in the attempt to do so they break down. The implication is that, in point of fact and practically, there are unequal standards of study to which the two sexes can respectively attain; and, if these standards are to be equalized, either the masculine standard must be lowered, so that the male students will not be pressed to their highest capacity of accomplishment, or the feminine standard must be raised, to the injury of female health. Our correspondent says that there is little question in regard to the facts, but that "woman is unfairly weighted for the race." Whether unfairly or not, she certainly is so seriously weighted that she cannot win in rivalry with her less-weighted competitor. The real question, then, is, whether this difference is accidental and removable, or whether it is radical and permanent, and belongs to the very constitution of the sexes. Upon this point we hope the Monthly will soon have something further to say.

"*BACKING OUT.*"

We are able to congratulate a number of our newspaper friends upon the happy relief they have experienced through the alleged "backing out" of Prof. Tyndall from the positions taken in his Belfast address. In the preface to that address he said that he had his moods of feeling like other people, but that "the doctrine of material atheism" did not commend itself to him in his hours of clearness and strongest conviction. And in his recent lecture on the "Crystalline and Molecular Forces," a revised copy of which we received from the author and have printed, he says that "the profession of that atheism with which I am sometimes so lightly charged" would be an impossible answer to the question "whether there is no power, being, or thing in the universe whose knowledge of that of which I am so ignorant is greater than mine." That is, in a word, Prof. Tyndall denies that he is an atheist, and this is called "backing out." "Backing out" from what? How can a man back out unless he has first gone in? When or where did Prof. Tyndall ever avow himself an atheist? Whether a man is an atheist or not, he ought to understand himself quite as well as his neighbors. "Oh! but his doctrines imply atheism! his science leads to materialism;" and so it turns out that Prof. Tyndall's atheism is imputed and constructive, something existing in the imaginations of those who worry themselves about other people's religion. It is curious to note how the tactics of those who assume to take charge of the religious concerns of others have been quite reversed in these later times. Formerly the manipulators of thumbscrews aimed to extract from suspected doubters the concession of religious belief—to make them acknowledge that they were Christians; now the policy seems to be to fasten upon them the imputation of disbelief whether they admit it or not. "No matter what you say—you are an atheist, and an atheist you shall be!" But it is said by the newspaper editors, "Prof. Tyndall declared solemnly before the British Association that there are great potencies in matter, and that he even discerns in it 'the promise and potency of every form of life,' which we hold to be the same as abolishing Almighty God, and we are not going to have that done." It is curious how every step of scientific advancement has been met in this way. When the question was one of the simplest physical actions in matter, that of the attraction of its masses for each other by a demonstrative mathematical law, there was the same intense solicitude about what was to become of the Deity. When Newton published the "Principia," even the great Leibnitz sounded the alarm, and affirmed that the English philosopher "had robbed the Deity of some of his most excellent attributes, and had sapped the foundation of natural religion." There is no trouble about *that* now. We can even discern how the operation of this grand and universal law, so far from being derogatory to the Infinite Power by which the universe is governed, must greatly expand and exalt our conception of the administration of Nature. And is it not barely possible that, by enlarging and deepening our view of the potencies of that unfathomable mystery we call matter, we are again heightening our view of the action of the Divine Cause? Vitality is manifested in matter, under the operation of law, just as truly as gravity or cohesion; order is admitted, at any rate, as a Divine institution. Suppose, then, we admit that life is a part of that order, and is ruled as other things around us are ruled, how is that going to vacate the universe of its Divine control? But it is not only not true that Prof. Tyndall, who is certainly the best judge of what he thinks, has ever declared his belief in atheism, but it is not true that his Belfast address implies it; and this his most intelligent and candid Christian critics have again and again acknowledged. He has never taken the position imputed to him even constructively. He has taken no position from which he has retreated. Who, then, *has* "backed out?"—those, of course, who have made the charge, and then withdrawn it.

LITERARY NOTICES.

Outlines of Cosmic Philosophy, based on the Doctrine of Evolution, with Criticisms on the Positive Philosophy. By John Fiske, M. A., LL. B. In two volumes. Vol. I., 465 pages; Vol. II., 523 pages. Price $6.00. J. R. Osgood & Co.

This long-expected work has at last made its appearance, and comes forth with such completeness that those who have been impatient of its delay will be glad that the author has taken the time needed to do justice to a formidable undertaking. In these two solid volumes of nearly a thousand pages, we have an exposition of the most advanced phase of philosophic thought, reduced to a comprehensive system, and presented in a style of rare felicity and attractiveness. Mr. Fiske combines the accomplishments of the scholar with the discipline of the logical thinker, and a large acquaintance with the modern aspects of knowledge, and thus qualified he has taken up the teachings of such men as Comte, Mill, Spencer, Darwin, Bain, Wallace, Lewes, Hamilton, Huxley, and many others, who have figured as leaders of thought in recent years, and, reëxpounding them with his own original additions, has given us a view so clear, comprehensive, and systematic, that its publication becomes an event in the progress of philosophy. But he is far from regarding the contributions of these various philosophers as of equal importance. Mr. Herbert Spencer he considers the colossus of modern thinkers—the peer of Newton, and the man who more than any other is directing the course of inquiry in the present age. His system he adopts with but slight reserve, and remarks in his preface: "Without implying that Mr. Spencer should be held responsible for every thing that is maintained in the following pages, I believe that the system here expounded is essentially his, and that such supplementary illustrations as I have added are quite in harmony with the fundamental principles which he has laid down."

But, while Mr. Fiske has been predominantly influenced in his thinking by the views of Mr. Spencer, and has produced a work which will have great value to the students of that philosopher, as presenting his doctrines in new aspects, and with fresh illustrations and applications, yet it is more than this—it is plainly the product of a course of thinking and study which has gathered materials from other regions of inquiry than those to which the English philosopher has chiefly devoted himself. We have here, not the work of a naturalist or a biologist, but rather of a literary writer, a student of history, philosophy, and theology, who, without presuming to speak with authority on matters of physical science, has still acquired an extensive familiarity with the methods upon which sound scientific conclusions are reached, and has derived from the various departments of natural knowledge no inconsiderable aid in forming and verifying his theory of things. Thus, while following Mr. Spencer's lead throughout the first half of the second or synthetic portion of the work, it is when he arrives at the chapters which deal with society (Part II., Chapters XVIII.–XXII.) that he is evidently most at home, applying, as he does, the generalizations of biology to the facts of human history, with a skill which brings out some novel results of prime scientific importance. One of those results, regarding the social development of man, is so significant as to justify some fullness of explanation.

The idea which determines the course of inquiry in the chapters referred to was first suggested by Mr. Wallace; and it is that, when the intelligence of an animal has arrived at a certain stage of flexibility, natural selection will begin to prefer mental to physical variations. That is to say, when an animal has become so intelligent that he can meet some of the exigencies of life by varying his intelligent contrivances instead of by incurring some slight physical change, there will then be a tendency for the more flexible intelligences to survive in the struggle for life; and obviously so much more can be done, and so much better done, by securing variations in mental rather than in physical structure, that after a while the amount of mental change will become enormously great and rapid as compared with the amount of physical change. Hence a man may be very much like an ape in physical structure, while his thoughts may be as much higher than the ape's thoughts "as the heavens are higher than the earth."

This is not only a very brilliant but a very useful suggestion. Mr. Wallace, however, has never followed it up, but has left it over for Mr. Fiske, who has applied it with such striking effect to the specific problem of the genesis of man, that he may almost be said to have made it his own. Before the problem of man's vast intellectual and moral superiority, Mr. Wallace retreats discomfited, even after having hit upon the idea which, when thoroughly considered, goes quite half-way toward explaining it; and, like other discomfited inquirers, past and present, he appeals to the supernatural for aid and comfort, when he was bound to go on and overcome the difficulties of the inquiry. Just here the question is taken up in the work before us. Having shown, in accordance with Darwin and Spencer, the general evidences for the evolution of the higher forms of life and intelligence from the lower forms, Mr. Fiske recognizes that the special question of the evolution of man's great mental preëminence requires a special mode of treatment. Some factor has come in which has greatly modified the phenomena with which we have to deal when considering the development of the animal kingdom in general. And this factor, Mr. Fiske maintains, is the existence of social combination, by which man is most conspicuously different from any other animal. The general question of the evolution of society is, therefore, treated preliminary to the question of the origin of man. Having ascended, zoologically and psychologically, from the primitive marine vertebrate to the point of departure of man from the apes, the line is changed, and a descent is made, psychologically and historically, from the higher to the lower phases of human society, with the view of reaching, as nearly as may be, the same point of departure. This inquiry into social evolution gives a formula for human progress, and lands us in the same general theory of primitive society which has been so well illustrated by Maine, Lubbock, and McLennan. The state, in its grandest complications, having been shown to be a development from the primeval clan or family group, very much as a complex organism is developed from the aggregation of amœba-like units, the question comes up, How did permanent family groups arise? Here we come to the very marrow of the problem, for, having passed from a race of primates in which each individual lives for himself, to a race of primates in which the conduct of the individual is determined with reference to the needs of a permanent group of which he is a member, we have then passed from man-like ape to apelike man. Both the intellectual and the ethical supremacy of man have been brought about by social conditions, of which this formation of permanent family groups was the earliest in order. How, then, was this great step taken?

Mr. Fiske gives an entirely new answer to this question, though when once suggested it is so obvious that it seems as if it ought to have occurred spontaneously to every one who has thought upon this subject. A preliminary to the answer is given in the chapter on the "Evolution of Mind," where it is briefly pointed out that the increase of intelligence in an animal, beyond a certain point, must give rise to a period of infancy, during which the career to be followed by the animal's plastic intelligence is determined by early experiences, but during which, also, the animal is unable to take care of itself. The full comprehension of this point depends on the understanding of as much of Mr. Spencer's psychological doctrine as is expounded in Mr. Fiske's work, and we have not space here to do more than state it. It is, however, familiar to every one that, as a matter of fact, apart from all theory, the growth of intelligence, as we rise in the animal scale, is attended by the appearance of a period of early helplessness, or infancy, which is longest in the highest animals, and is very long in the case of man. It is also a very familiar fact that, where this period of helplessness occurs, there is an accompanying appearance of parental affection and approach toward domesticity in the adult members of the race. These facts give the needed clew to the solution of the problem about the origin of family groups. When once we have have two or three children to take care of, the later ones being born before the elder ones are able to shift for themselves, we have the crude shape of a primeval family group or clan, and have passed from animality which is non-social to animality which is social—that is, to rudimentary humanity.

There appears to be no gap left in this explanation. The intelligence, according to Mr. Wallace's suggestion, is acted upon more and more by natural selection, physical variation taking a subordinate place. By-and-by the growth of intelligence becomes so considerable as to extend beyond the fœtal period into the early years of life. There results a period of helplessness which, when sufficiently prolonged, causes family associations to become permanent, and thus gives rise to society. And it is further observed that this period of helplessness is also a period of plasticity; so that each generation need no longer strictly resemble preceding generations, but may have a slightly different twist given to it in youth, thus making possible a great acceleration of mental progress.

This beautiful generalization, it cannot be denied, throws new and important light upon the obscure and difficult question of the intellectual and social development of man; and, if Mr. Fiske had done nothing more, it would establish his reputation as an original thinker in one of the highest departments of philosophical investigation. But the most interesting part of the work to many readers will, no doubt, be the six chapters of "Corollaries," which discuss the bearings of the doctrine of Evolution upon religion. Those who expect to find in every upholder of development a materialistic atheist, one who—as the *Nation* said of Dr. Büchner—not only expects to die like a brute, but congratulates himself that he is going to die like a brute, will no doubt be somewhat taken aback by the chapter on "Matter and Spirit," in which it is asserted with emphasis that "the latest results of scientific inquiry, whether in the region of objective psychology, or in that of molecular physics, leave the gulf between mind and matter quite as wide as it was judged to be in the time of Descartes. It still remains as true as then, that, between that of which the differential attribute is Thought and that of which the differential attribute is Extension, there can be nothing like identity or similarity."

A notable point of originality is the treatment of religion as the highest psychical phase of that life which consists in the adjustment of inner to outer relations. He regards religion as the manifestation of that striving after complete harmony of psychical life with its requirements, stimulated by the sense of sin or moral shortcoming, for which the analogy is furnished by that striving for mere physical adjustment throughout the animal world, to which the sense of pain is the prompter. This view, as Mr. Fiske maintains, detaches religion from theology, and enables philosophical speculation to proceed to the utmost lengths without fear of detriment to that which men really value in religion, and for the sake of which they cling to the formulas, often absurd or inadequate, in which it is enshrined.

We cordially recommend this valuable work to all who are interested in philosophical questions; and especially to those who are desirous of knowing the latest currents and drifts of speculative inquiry.

Report of a Tour of Inspection of European Light-House Establishments, made in 1783. By Major George H. Elliot, Corps of Engineers U. S. A., Engineer Secretary of the Light-House Board. Washington: Government Printing-Office, 1874. Pp. 288.

This is a very complete account of an inspection of the light-house systems of England and France, made by Major Elliot under instructions from the Light-House Board, and it is a work which will be of great value, technically, to the engineer of light-houses, besides being an extremely interesting recital of the principal features of the European systems. Major Elliot's facilities for observation seem to have been excellent, and it is evident that the time at his disposal was thoroughly utilized. From his very clear report a lucid idea of the principal points of difference between transatlantic systems of lighting and our own is obtained; and the book is profusely illustrated with woodcuts and maps, which serve to explain more fully the leading features of each system.

A very large number of the lights on the North Sea and on the southwest coast of England, as well as several of the more important lights of Ireland, were personally visited and minutely inspected, and full details are furnished with regard to all important points. Minute accounts are given of many of the newest and most approved devices for increasing the effective power of light-houses and light-ships, and the author has not hesitated to propose such changes in our own light-house service as his experience leads him to believe most necessary.

Besides devoting much attention to the subject of illuminating apparatus for coasts, Major Elliot has considered the question of fog and danger signals, and has personally seen many experiments on their relative efficiency. The American steam-siren, now in use on our own coasts as a fog-signal, Major Elliot considers the best device for the purpose; and the Trinity House Board (in charge of light-houses in England) has officially signified its concurrence in this opinion. Some of the changes which he thinks should be made are noted below, and his reasons for advocating these changes seem to be entirely satisfactory:

(*a.*) An increase in the illuminating power of our lamps:

"While the power of our light-house lamps is fixed (i. e., they give only the same amount of light in foggy and thick weather as in fair, in the long twilights of summer as in the darkness of winter), the English oil-lamps are flexible in power, and can be varied by the keepers to suit the varying conditions of the atmosphere. . . . The first-order sea-coast lights of England may be raised from an equivalent of 342 candles (their minimum) to 722 candles, while the maximum power of our first-order sea-coast light is uniformly the equivalent of only 210 candles."

(*b.*) The adoption of mineral oil, instead of animal or vegetable oils:

"It is more cleanly than the lard-oil consumed in our light-houses; it is not injuriously affected by the severest cold; the lamps are more easily lighted, and do not require to be trimmed during the longest nights, thus making commerce less dependent on the watchfulness of the keepers; while its cost is but little more than one-third of that of the latter oils."

(*d.*) The establishment of gas or electric lights at important points on our coast. Major Elliot mentions a light-house of this character in England which gives a condensed beam of light equal to more than 800,000 candles, while our own light-houses can only give the equivalent of a little over 200!

. . . .

(*i.*) The adoption of a new method of appointing and promoting light-house keepers:

"The rules of the European light-house establishments in regard to the appointment and promotion of keepers, on whom the utility of light-houses and the safety of life and property so largely depend, are fully described in the report, and the facts are noted that for each light the number of keepers is smaller than in our service; that they are furnished with circulating libraries; that their pride in their profession is stimulated by being furnished with a handsome uniform dress; that they are promoted for merit; that they are educated with care for the management of lights before they are intrusted with the charge of them; that their lives are insured for the benefit of their families, and that they are pensioned when superannuated; none of which obtain in our own service."

(*k*.) The placing of revolving lights on our light-ships. Experience has shown this to be possible, as in Great Britain 30 out of 43 light-ships have revolving lights, while in our own service the only lights so placed are constant.

These recommendations are well worth the consideration they will obtain, for the subject is an important one, not only to light-house boards, but to all those who "go down to the sea in ships," as who does not in these days of steam? E. S. H.

History of the Conflict between Religion and Science. By John William Draper, M. D., LL. D. 373 pages. Price $1.75. D. Appleton & Co. International Scientific Series, No. XII.

This second American contribution to the "International Scientific Series" was published December 4th, simultaneously in London and in New York. Translations of it into the Continental languages are in rapid progress, and it will be shortly published in Paris, Leipsic, Milan, and St. Petersburg, so that the views presented by the writer will thus promptly be laid before the leading minds of the civilized world—thanks to the progress of science, which has given us these vast facilities of rapid intercommunication and diffusion of knowledge, and created a liberal public sentiment in all the leading nations by which the expression of advanced opinions is welcomed and appreciated. No more appropriate work could have been done at the present time than to write the history of that long and terrible conflict between the agencies of intolerance and of liberalization which has given rise to modern civilization, and triumphed in that large measure of free opinion which the present age enjoys. In writing such a history, Dr. Draper has done an important service to his time.

Our readers have been already apprised of the nature of Dr. Draper's work, through the statements of the Preface, which appeared in the December Monthly; and elsewhere, in the present number, we have spoken of its bearing upon great questions now extensively agitated in the public mind. It only remains to add that it is a book to which no notice or review can do justice, because it requires to be read as a whole, like a novel with a well-sustained plot. It is a book crowded with varied information, presented in historic unity, a monograph illustrating and elucidating a single great idea. One of the incidental characters of the volume is the large amount of interesting information it contains regarding the progress of scientific knowledge. Dr. Draper gives us a succession of vivid pictures of the state of actual science among the early Greeks and the later Romans, at the birth of Christianity, at the epoch of the "Fathers of the Church," in the middle ages, at the period of the rise of modern knowledge, at the time of the Reformation, and in the present century. We know of no work that can compare with this volume in the clearness and fullness of its summary of man's scientific achievements from the birth of knowledge to the present time; and, although these copious facts have been gathered and digested by Dr. Draper for the elucidation of his main subject, they are nevertheless of great value and interest, independent of the use he makes of them. All parties are certain to appreciate and enjoy this valuable portion of Dr. Draper's book.

We are constrained also to call attention to the admirable character of the work as a literary exposition. We often hear about the "dryness," and "repulsiveness," and "hard technicality," and general dullness of scientific writers, and the objection is often too well taken, but it does not apply to Dr. Draper. He writes with a clearness, a simplicity, and a warmth of feeling, that give pleasure to the reader, and he thus gains the chief object of an interesting style. Though a discoverer in science, and one who has spent a large portion of his life in the laboratory, and written many original scientific memoirs, he is not the victim of these pursuits, but has cultivated the graceful in literature and given play to imagination, not only in his beautiful researches, but also in his pages, which are often models of forcible and impressive statement. There are many passages in his writings which, for felicity of expression and sheer eloquence, deserve to be placed among our gems of literature, and the reader will find many such examples in his newly-published volume. We are impelled to call attention to this feature of the work, because the current notion of the unattractiveness of scientific writers is often made an excuse for neglecting valuable scientific books, and we wish to apprise those who are addicted to this habit that the excuse is not valid in the case of the present work.

Chemical and Geological Essays. By Thomas Sterry Hunt, LL. D. 489 pages. Price, $3.00. J. R. Osgood & Co.

Among the multitude of compilations and digests upon scientific subjects, which have been latterly put forth on both sides of the Atlantic, by men whose names lend no weight to their work, we welcome this substantial volume by one who has devoted his life to the original and independent study of the subjects with which it deals, and whose high reputation, and the honors he has received from learned societies both at home and abroad, give the best assurance of the valuable character of his labors. Dr. Hunt has done the public an excellent service, in collecting and republishing his chief scientific memoirs. His volume, indeed, was wanted. We have many and excellent text-books of geology and text-books of chemistry, but something like a comprehensive text-book of the relations of these two sciences was a desideratum in our scientific literature which this work will go far toward supplying. For, although it was prepared for no such purpose, and although its papers were produced at different times in the course of a life devoted to research, and of course bear the stamp of the author's views, yet its statements of facts are to be thoroughly trusted, while their theoretic interpretations are so presented as to give us the latest views that science has reached respecting them. The volume is both a representation of the present state of knowledge upon chemical geology and of the growth of that knowledge during the past generation. In no field has there been greater activity of investigation, and, while Dr. Hunt develops the views to which his own studies have led him, he gives us at the same time the opinions entertained by others, or previously accepted, so that the reader is well instructed upon the subject, and is able to form an intelligent judgment for himself. The following passage from his preface will give an idea of the extent of the topics considered. The author's "researches and his conclusions as to the chemistry of the air, the waters, and the earth, in past and present times; the origin of limestones, dolomites, and gypsums, of mineral waters, petroleum, and metalliferous deposits, the generation of silicated minerals, the theory of mechanical and chemical sediments, and the origin of crystalline rocks and vein-stones, including erupted rocks and volcanic products, cover nearly all the more important points in chemical geology. They have, moreover, been by him connected with the hypothesis of a cooling globe, and with certain views of geological dynamics, making together a complete scheme of chemical and physical geology." Since the appearance of Bischoff's treatise on chemical geology, twenty years ago (it was never republished in this country, and if we are not mistaken it is now out of print), we have met with no book that so fully covers the ground as this collection of essays. It will be valuable for reference to the students of economical geology, and interesting to general readers who care to understand any thing about the great agencies of Nature which have produced, and are still carrying on, the changes in the crust of the earth. It will at once take its place in the libraries of scientific men, and should be introduced for reference into all schools where chemical and geological science is studied.

The Principles of Sociology. By Herbert Spencer. Part I. Eighty pages. Price, 50 cents. Published quarterly. $2 a year. D. Appleton & Co.

After an interval of some delay, Mr. Spencer resumes the course of his philosophical serial, and has now entered upon what will generally be regarded as its most important part. There has been much impatience, with many, that he has been so slow in reaching the practical and pressing problems of social science which he was expected to handle with originality and power; and readers have complained of the prolonged discussions in biology and physiology which seemed to have nothing more than a speculative importance. But we already begin to see that Mr. Spencer understood what he was about in his thorough elaboration of those subjects. It was like the Brooklyn Bridge: the two piers have to be sunk deep and raised high before the useful roadway can be placed. A science of society is impossible, except upon the basis of a science of life and a science of mind which can furnish principles for the interpretation of social facts. Having developed and stated these principles, Mr. Spencer can now use them, and has only to refer his readers back to the places where they have been fully expounded. Because there has been neither a biology nor a psychology that was available, nor any systematic collection of social facts as data for reasoning, there has hitherto been no proper science of sociology; but, having secured these imperative prerequisites with a fullness never before even attempted, Mr. Spencer enters upon the present stage of his philosophical enterprise with a preparation that gives promise of the most valuable results.

We published, some time ago, from advanced sheets, an installment of Mr. Spencer's opening argument on what he terms the original external factors of social phenomena. The first forty pages of the present number are devoted to an enumeration of the social factors of all orders, original and derivative, which enter into the constitution of human societies and influence their development. These are extrinsic, or those which pertain to the conditions of external nature, and intrinsic, or those which pertain to the constitution of man, the social unit. The passages that we have already published are from the former portion of the argument, which considers the climatic conditions favorable to social unfolding. There has formerly been much said about the influence of the aspects and conditions of Nature in determining the character of social life; but, while this is an element of the case of much importance, and not to be neglected, it is still of minor moment as regards evolution, when compared with the internal factors which belong to human nature itself. In Chapter IV., Mr. Spencer passes to the consideration of these internal factors, and devotes Chapter V. to the primitive man in his physical characteristics. Chapter VI. deals with the emotional natures of primitive men as affecting their social relations and possibilities of progress. We publish, in the present number of The Monthly, a few passages from this chapter, which may serve to illustrate the indispensableness of psychology to any thorough scientific treatment of the subject.

We recommend all interested in the study of social questions to subscribe for this work. The terms are so moderate as to be hardly burdensome to any; while the discussion from the foremost thinker of the age, who has devoted his life to this great subject, will give the ripest results of scientific investigation upon problems which are becoming every day of deeper interest to all thoughtful persons.

The Common Frog. By St. George Mivart, F. R. S. London: Macmillan & Co. 1874. 12mo, 158 pp. Price $1.00.

This is one of Macmillan's "Nature Series," and an excellent little book it is. The author opens with the question, "What is a frog?" and by way of answer gives us not only a clear and instructive account of the structure, varieties, and distribution of that animal, but in defining its position in the animal world tells us a good deal about its near relations, and about zoology generally. Though to many an uninteresting and repulsive creature, the frog is really entitled to great consideration on account of its services to science. Says Mivart: "The frog is the never-failing resource for the physiological experimenter. It would take long, indeed, to tell the sufferings of much-enduring frogs in the cause of science! What frogs can do without their heads? What their legs can do without their bodies? What their arms can do without their head or trunk? What is the effect of the removal of their brains? How they can manage without their eyes and without their ears? What effects result from all kinds of local irritations, from chokings, from poisonings, from mutilations the most varied? These are the questions again and again addressed to the little animal which, perhaps more than any other, deserves the title of the 'Martyr of Science.'" The book abounds with interesting facts concerning the habits of frogs and nearly-related forms; and the whole is written with a clearness and simplicity of style which, without impairing its scientific accuracy, make it easy for the general reader. It would have been improved in this respect, however, had a glossary been appended. A few examples of want of care in the use of classificatory terms, and occasional indications of careless proof-reading, are blemishes that may be corrected in a second edition.

PUBLICATIONS RECEIVED.

Report of the Commissioners of Agriculture for 1872.

Practical and Critical English Grammar. By Noble Butler. Louisville, Ky.: Morton & Co. Pp. 312. Price, $1.00.

Polarization of Light. By W. Spottiswoode, F. R. S. New York: Macmillan. Pp. 130. Price, $1.00.

Organic Chemistry. By W. Marshall Watts. New York: Putnam's Sons. Pp. 130. Price, 75 cents.

Practical Theory of Voussoir Arches. By William Cain, C. E. New York: Van Nostrand. Pp. 118. Price, 50 cents.

The Foes of the Farmers. By A. L. Perry. Nebraska Board of Agriculture. Pp. 20.

Missouri Iron-Ores. By Adolf Schmidt, Ph. D. Jefferson City, Mo.: Regan & Carter. Pp. 16.

Climate of the Glacial Period. By Thos. Belt, F. G. S. Pp. 44.

Habits of Some American Species of Birds. By Thomas G. Gentry. Pp. 16.

Researches in Acoustics. Paper V. By Alfred M. Mayer. Pp. 42.

Drift of Medical Philosophy. By D. A. Gorton, M. D. Philadelphia: Lippincott & Co. Pp. 70.

Supplement to the Calculus of Operations. By John Patterson, A. M. Pp. 8.

Longevity of Brain-Workers. By Geo. M. Beard, M. D. Pp. 16.

National Teachers' Monthly. New York: Barnes & Co. One dollar per year.

Legal Relations of Emotional Insanity. By E. Lloyd Howard, M. D. Pp. 12.

The Analyst: Journal of Pure and Applied Mathematics. Des Moines, Iowa. Two dollars per year (bi-monthly).

MISCELLANY.

Climate of the Glacial Period.—This subject is discussed, in the October number of the *Quarterly Journal of Science*, by Mr. Thomas Belt. The cold of the glacial epoch, he thinks, was caused neither by elevation of the land in high latitudes, nor by the position of the earth due to the eccentricity of its orbit, as suggested by Lyell, Croll, and others; but rather by great obliquity of the ecliptic. If the axis of our globe be as that of Jupiter, the days and nights would be twelve hours each, and there would be no succession of seasons. The hot climate of the equator would become more temperate toward the poles, and no snow could accumulate at the sea-level, except, perhaps, immediately around the poles.

With beginning of obliquity of the sun's path, seasons of heat and cold would succeed each other, and these would become respectively lengthened and intensified as the obliquity increased. The long winters of intense cold would cause great accumulation of snow, which the summer could not melt. A climate is made more severe by presence of ice and snow, as many of the sun's rays of both heat and light are reflected, and the earth is not warmed by them. Thus, whatever tends to increase the area of snow increases the severity of the climate. The growth of the ice-sheet would cause it to extend toward the equator, and the movement of warm currents might be arrested. The heat of their waters, before expended in melting ice in the polar regions, would now produce great evaporation along the margin of the ice-belts, and the source of rainfall be augmented.

The great obliquity of the sun's path, contended for by Mr. Belt, exists in the planet Venus, where the tropics overlap the polar circle, and a similar state of things here would give us the glaciers as they existed in the ice-age. Moreover, a change in its obliquity back until the sun's path was over the equator, would give the climate which produced tropical plants within the polar circle. The fact of their existence demonstrates the presence there of a mild climate—as enormous unmelting glaciers prove a climate of intense and continued cold.

The cause of change in the sun's path he finds in changes in the distribution of the matter of the earth. He cites the fact of the earth's equatorial protuberance, and says the mass takes the form of an ellipse, and is not circular, as assumed by some mathematicians, and is itself a cause of change, altering the poles of rotation and the sun's path. Moreover, much may be due to former upheavals and depressions of the earth's crust. The increase of polar ice is, according to Mr. Belt, contemporaneous with increase of obliquity of the sun's path, and must diminish the difference between the earth's equatorial and polar diameters. The tendency of this would be to diminish the obliquity of the sun's path, ameliorate climate, and approximate to a uniformity of seasons and of day and night.

The coming of the cold climate, and consequent increase of polar ice, he thinks was gradual and continuous, and he finds no evidence in Scotland, or elsewhere, of interglacial periods of mild climate. Mr. Belt claims that the glaciation of the north and south poles was simultaneous, as the climate north and south of the equator must have been nearly the same.

This accumulation of ice at both poles accounts, in Mr. Belt's opinion, for several phenomena usually attributed to elevation of land. He thinks the level of the ocean must have been lowered not less than 2,000 feet to supply the ice-sheets.

In the ice once formed upon the polar regions, Mr. Belt finds a dynamic agent adequate to important geological changes. Thus their weight would cause the polar lands to sink until the earth attains its normal form; by their melting, and flowing toward the equator, the equilibrium is disturbed. But the disturbance from this cause is probably very small, "if," as Mr. Belt concludes, "the earth's interior be as cold as space, and movements occur only in its upper strata."

An Ornithological Land-lubber.—Toward the end of last December, the Challenger expedition visited Prince Edward's Islands, situated about 1,100 miles southeast of the Cape of Good Hope. We find in the *Times* the following notes concerning the habits of the albatross, a bird which frequents these islands in enormous numbers: "The whole of the wet, sodden, flat lands of Marion Island, one of the group, were studded with albatrosses, sitting on their nests. The magnificent birds, most of whom were asleep, covered the ground in such numbers that they looked like a flock of sheep scattered over a meadow. The nests were freshly covered with tufts of grass and moss, and stood some two feet above the swampy ground. It was evidently the beginning of the breeding-season, as few eggs were attainable. These splendid birds, weighing 19½ pounds, and measuring 10½ feet from tip to tip of wing, seen to such advantage while in their glory at sea, so evidently at home as they sweep gracefully through the air, are, on land, 'completely at sea.' It appears impossible for them to hover; so, on alighting at the end of a swoop, the momentum of the body continues after their feet have touched the ground, until they literally turn head-over-heels on to their backs, from which inglorious position their efforts to regain their equilibrium are any thing but graceful. While advancing to the nest, the neck is extended and the body lowered, as they waddle along, like a goose. To rise in the air, they are obliged to run, with extended wings, for some 200 yards, over the soaking grass, before they attain sufficient velocity for the air to get under their wings, and allow them to feel themselves again masters of the situation. Once landed, they are powerless to resist attack: a sharp snap of the beak is their only means of offense or defense. In taking their eggs, the readiest way is to push them backward with a stick forced against their breast, which, balanced as they were, on the edge of the raised nest, was easy work, the drop of two feet being just sufficient to send them on to their backs and prevent them rising, until after the prize was captured."

Decomposition of Eggs.—For some time before his death, Dr. Grace-Calvert was engaged, in company with Mr. William Thomson, in investigating the subject of the decomposition of eggs. From these researches, as now published by Mr. Thomson in the *Chemical News*, it appears that eggs, when the shells are intact, can only be decomposed by one, two, or all of three different agencies. The first of these agencies is *the putrid cell.* This may be developed in the egg, however effectually the shell is protected against spores from without, or the diffusion of gases; it is generated from the yelk. Certain gases have the effect of retarding or preventing its growth, as carbonic dioxide and coal-gas, but it is promoted by oxygen. One egg, which had for 118 days remained in an atmosphere of oxygen, was found to be decomposed entirely by "putrid cell;" the yelk had expanded, and was thoroughly mixed up with the white, and the contents emitted a putrid smell. The atmosphere, once pure oxygen, on analysis showed only a fraction of one per cent. of that gas, while the amount of carbonic dioxide was 95 per cent.

The second agency in decomposition is a vibrio, which in all cases comes from without, and never exists originally in the egg. Whole eggs that remain dry, exposed to the atmosphere for any length of time, are never attacked by this animalcule; but, if the outside of the shell becomes moist, the vibrios floating in the atmosphere fall on it and develop in the contents. The third agency is a fungus, the *Penicilium glaucum*, which exists suspended in the atmosphere. If whole eggs are placed in a constant draught of air, but few will be attacked by this fungus; but, if they are left in a stagnant atmosphere, the floating spores will settle on the shell, and send their long fibres through it into the contents. This fungus cannot grow in an atmosphere of carbonic dioxide, but in oxygen its growth is most luxuriant. In some cases of decomposition by the penicilium the egg was found to appear as if it had been perfectly coagulated by boiling. The filaments of the fungus branch about in immense numbers in all directions, twisting and twining into each other among the contents.

Experiments on the Living Human Brain.—Some experiments, made by Dr. Bartholow, of Cincinnati, on the living human brain, having drawn upon him the sharp censure of sundry professional journals, he has offered an explanation of his conduct in the *British Medical Journal.* "The person on whose brain the experiments were made was," he writes, "hopelessly diseased with a rodent ulcer, which had already invaded the *dura mater;* life could not have lasted much longer in any case. The patient herself consented to have the experiment made. The experiment consisted in applying electricity to the brain, as in Ferrier's researches, and it was believed that fine insulated needles could be introduced without injury, for the following reasons: The brain has been successfully incised to discharge pus. Portions of the brain have been lost without fatal injury to the patient. Then, the faradic current was used, which has no electrolytic action. In the present case it was the ulcer, not the puncture of the needles, that caused death." Dr. Bartholow concludes his letter as follows: "Notwithstanding my sanguine expectations, based on the facts above stated, that small insulated needle-electrodes could be introduced without injury into the cerebral substance, I now know that I was mistaken. To repeat such experiments with the knowledge we now have, that injury will be done by them, would be in the highest degree criminal. I can only now express my regret that facts which I hoped would further, in some slight degree, the progress of knowledge, were obtained at the expense of some injury to the patient."

The Struggle for Existence.—Mr. Buckland recently fought a pitched battle in the Round Pond, Kensington Gardens, with the innumerable hosts of a crustacean parasite that was destroying the fishes. Having learned that there was something wrong at the pond, Mr. Buckland went there to make a reconnoissance, and found, at one point, some little distance from the bank, a dense "cloud of fish." Having waded into the midst of them, he discovered that the supply-pipe, through which fresh water was admitted to the pond, was nearly choked up. The fish wanted fresh water, evidently. He took up with a landing-net one or two of those that were most sickly, and found them literally covered with parasites. Various means were tried for removing the parasites, the most expeditious way being the use of a stiff brush, with sand. Having thus taken out of the pond, cleaned, and returned again to the water, many hundred fish, it was discovered that the labor was in vain, for the parasites were so numerous that soon the fishes were infested again. The crustaceans plainly were holding their own. Mr. Buckland now cleared away the mud in front of the pipe, so that the fish might have a chance of rubbing off their tormentors against the bottom. He next conceived the idea of spreading a quantity of gravel about the pipe. With the aid of this and an abundant supply of fresh water at a low temperature, the fish were enabled to rid themselves of their parasites easily, and, in the cooler water, the latter did not find the conditions of life so favorable.

A Worm that the Sparrows refuse.—We recently noted the appearance in the public parks and squares of Philadelphia of a caterpillar which threatened to destroy the the trees. The English sparrow had effectually exterminated the measuring-worm in those parks, but showed no disposition to attack this new destroyer of the foliage. At the late meeting of the American Association, Dr. John L. Le Conte described this insect as the larva of the moth *Orgyia leucostigma*. It is a slender caterpillar, covered with stiff yellow-and-black hairs. The sparrow does not attack it, being deterred, probably, by the bristles, by which it is protected. But, fortunately, the nuisance can be abated without the aid of the sparrows. When the caterpillar has attained its full growth on the tree, it crawls to a neighboring wall or fence, and there, fixing its cocoon, undergoes transformation. The remedy against the annoyance is now very simple, viz., by sweeping the cocoons from the walls and fences with stiff brushes, and placing around the trees rings of tin-plate inclined at an angle. This will give the trees immunity, because the insects are not provided with wings for flight.

A New Source of Illuminating Gas.—An oil-bearing shale of considerable thickness, called Kimmeridge coal, or clay, underlies the whole county of Dorset, and is met with in other parts of England. Various attempts have been made to utilize this deposit for the purpose of producing light and heat, but with little success hitherto. Now, however, the Rev. Henry Moule has succeeded in devising a method of producing from it a good, useful gas. The new gas is obtained by the destructive distillation of the shale, the gaseous products being submitted to purification before use. In this latter process, as also at other stages of the manufacture, chalk is used. The gas itself, though not odorless, is by no means so pungent nor so unpleasant as ordinary coal-gas. During combustion no odor is perceptible, and, so far as can at present be ascertained, the products of combustion contain no noxious gases. Besides the gas, a pungent oil is produced, which Mr. Moule believes can be rendered comparatively odorless, and may with advantage be applied to various purposes. The inventor also proposes to utilize the heat-giving properties of shale and chalk for heating, both by means of gas and in a direct manner, his plans having been matured in this respect.

Contagious Ophthalmia. — In English poor-houses and "pauper-schools," contagious ophthalmia has, from the foundation of such institutions, afflicted the inmates. It is produced by unsanitary conditions of life—want of cleanliness, overcrowding, ill-ventilation, etc. It might be supposed that these establishments would have been greatly improved in later times, owing to the increased attention now bestowed on public hygiene; but the contrary is the fact, as we learn from a discourse by Dr. Brudenell Carter. A serious charge is brought by this gentleman against the Poor-Law Board, viz., that during the last few years their unwisdom has developed this malady in workhouses and pauper-schools "in a manner to which previous English experience affords no parallel." The Government has refused to let the truth be seen, but Dr. Carter has been able to obtain, from a private source, a copy of a report made to an official inspector by the medical officer of one of the schools. It states, among other curious matters, that, of 1,062 children in the school in question, only 182 had escaped ophthalmia; 163 had suffered from one attack of the disease, 151 from two attacks, 110 from three, 75 from four, 54 from five, 58 from six, 22 from seven, 25 from eight, 7 from nine, 11 from ten, and 204 from more than ten attacks. In a considerable proportion of these cases sight would eventually be greatly impaired, and in many it would be wholly lost.

Portuguese Agriculture.—The art of agriculture is in a very primitive state in Portugal, the instruments of husbandry employed being very little different from those in use during Roman times. Two kinds of ploughs are used, both very rude. The harrow, too, is of the rudest construction, having 15 to 20 teeth of iron or wood, set quincunx fashion into a strong, oblong-square wooden frame, with one cross-bar. As a substitute for the roller, the harrow can be reversed, loaded with stones, and drawn sledgewise over the land. The hoe is indispensable in Portuguese field-husbandry; ground can be prepared by it for seeds, or for planting, more quickly than it can be dug by a spade, though it is less completely stirred and turned over. The cart has two low wheels of solid wood, with iron tires, fixed immovably to an axle which revolves with them. The yoke is fixed to the necks of the oxen, or, in some localities, to the horns.

Lightning among a Flock of Geese.—A singular occurrence, which took place on March 16th, in the northern part of Sutter and the southern part of Butte Counties, Cal., is narrated as follows in the *Sutter Banner:* "On that day, just before sunset, a large thunder-cloud came up, apparently from the northeast, accompanied by an unusual amount of chain-lightning. First a small amount of hail fell, and then followed sufficient snow to whiten the ground. As the hail began to fall, and the lightning flashed, thousands of wild-geese, which were in the ponds of shallow water which exist in that locality during very wet winters, suddenly rose up in a great flutter, as if many hunters had discharged a volley among them. They went up and up, apparently to rise above the fearful cloud. It was nearly dark, and those who saw them rise thought no more of it until morning, when they began to find dead geese, and hear of hundreds being picked up by the neighbors. Some 700 were found. One man picked up on his farm all that two horses could haul. Their heads were badly torn, and their bills split into fragments. The portion of the country thus affected was about a mile and a half wide, and reached several miles into Butte County. The terrific lightning in this cloud was witnessed by people on the Honcut, in Yuba County, and in the central portion of Sutter. The thunder was heard at the distance of twenty miles."

Artificial Furs.—A new method of treating fur has been patented in England, by Mr. Joseph Tussaud, one of the proprietors of the well-known wax-work establishment founded by Madame Tussaud. Mr. Tussaud removes the hair or fur from the skin, substituting for the latter an artificial skin. First, the piece of fur to be treated is soaked in lime-water, for the purpose of loosening the hair. Then it is washed in water, and hung up to dry. Next, it is laid on a board, with the hair-side up, and a solution of glue applied, care being taken not to disturb the natural position of the hairs. The glue having dried and become hard, holds the hairs so firmly as to allow the natural skin to be pulled off. An artificial skin is now applied to the roots of the hairs, by pouring over them liquid India-rubber, boiled drying-oils, or other water-proof substances, which, on drying, will form a continuous membrane supporting the hairs. The glue is then removed by steeping the fur in warm water. Furs prepared in this way are moth-proof, and superior to the natural skin for many purposes, such as mats, rugs, etc. After the removal of the hair, or fur, the skins are still available for the manufacture of leather.

Siamese Medicine.—A Siamese manual of medicine contains the following recipe for a poultice to cure snake-bite: "Take the eyes of vultures, crows, and cats, together with three sorts of animal deposits found on trees; mix all these together, then place nine wax-candles on as many floats made of plantain-stalks, each ornamented with flowers. After this, let the doctor make an offering of nine silver coins, nine handfuls of rice, nine ceri-leaves, and nine betel-nuts, placing a set of each on the several floats, in honor of the teacher of medicine. Then he is to launch the floats into the river, mould his paste composition into slugs, gild the slugs, and apply them to the wound." Another way of treating snake-bites is the use of enchantments for calling the snake which gave the wound to suck the poison out. "For this purpose, fill three bottles with proof-spirits, then let the doctor repeat the form of incantation, drinking one of the bottles of spirits up, while he enchants over it. If the snake does not come, the doctor is to drink a second bottle, proceeding in the same way; and if, on consuming the third bottle, the serpent still declines to appear, the patient must die. But, should the snake present himself, let the doctor take three cowries in his hand, and seven times rehearse a set form of incantation till he has charmed the snake to come to his left side. Then the poison is to be brushed from the wound with a handful of meyon-leaves seven times, and the patient, if he can be got to eat a betel, will recover." Civilized practice, it may be observed, does not stop with three bottles of spirits, but continues the drinking till the snakes appear!

Fossil Remains of the Moa.—According to the *Melbourne Argus*, a number of bones of the *moa* have been discovered near Hamilton, New Zealand. The moa has never been seen alive since about the year 1650. Tradition describes it as a stupid, fat, indolent bird, living in forests and mountain-fastnesses, and feeding on vegetable food. The moa seems to have been extirpated for the sake of its flesh, feathers, and bones. The natives used the bones for making fish-hooks, and the skull was employed as a receptacle for holding tattooing-powder. Captain Hutton, the provincial geologist, has lately visited the locality where the bones were discovered, and ascertained from personal observation that an accumulation of these bones exists, in a tolerable state of preservation, in a swamp about a mile and a half east of Hamilton. Mixed with the moa-bones were found skeletons of the *aptornis*, a large bird, resembling a swan. There are also the bones of some smaller birds, and these will prove of peculiar value, as hitherto paleontological research has not offered much information as to the kind of small birds which were contemporaneous with the moa. It is estimated that about five or six wagon-loads of bones lie in the swamp at Hamilton.

The Pitcher-Plant.—In a paper read at the American Association, Prof. C. V. Riley gives the following description of the pitcher-plant (*Sarracenia*): The leaf of this plant is a trumpet-shaped tube, with an arched lid, covering more or less completely the mouth. The inside is furnished with a perfect *chevaux-de-frise* of retrorse bristles, commencing suddenly about an inch from the base; thence decreasing in size until, about the middle to the mouth, they are so short, dense, and compact, as to form a decurved pubescence, which is perfectly smooth and velvety to the touch, especially as the finger passes downward. Running up the front of the trumpet is a broad wing, with a hardened border, parting at the top and extending around the rim of the pitcher. Along this border, but especially for a short distance within the mouth, and less conspicuously within the lid, there exude drops of a sweetened, viscid fluid, which, as the leaf matures, is replaced by a white, papery, tasteless sediment, or efflorescence, while at the smooth bottom of the pitcher is a limpid fluid, possessing toxic qualities. The insects which perish in this liquid are numerous, and of all orders, but ants are the principal victims. The plant, however, is omnivorous as regards insects, and Prof. Riley has found in the fluid, at the bottom of the pitcher, katydids, locusts, crickets, cockroaches, flies, moths, and even butterflies, in a more or less recognizable condition.

Effects of the Glacial Epoch on the Distribution of Insects.—In a paper entitled "On Allied Species of Noctuidæ inhabiting Europe and America," Buffalo, October, 1874, Mr. Grote says: "For the origin of certain species we shall have to go backward to the Pleistocene, and consider the identical species as belonging to a former Arctogæal fauna. The action of the steady increase of cold which characterized the gradual inauguration of the Ice period would have been to drive the insects southward and mix the Arctogæal with the then existing 'indigenous' southern species. The summers of the middle Glacial epoch probably afforded no opportunity for the existence of Noctuidæ throughout the Northern States. On the decline of the Glacial epoch, and with a steady increase of warmth (still continuing), the species would progress northward again. We may regard such a species as *Fidonia fimitaria* G. & R., found in Texas, as an outlying colony of *F. fasciolaria* forced southward and retained by local influences, and possibly having submitted to the modification which enables us at this day to separate the two forms. During the Pliocene, the common ancestor of the two forms may have been different from either. During the Pleistocene, Holocene, and Recent periods, we must consider such species as *Hadena arctica* to have preserved their identity, while many may have perished or submitted to modifications, and these latter may be represented by the closely-allied species of the two faunæ. The Glacial epoch may then supersede the 'Atlantis" of those entomologists who looked for a geographical connection in former times to account for the existence of identical or representative species on the two continents."

The Pottery of the Mound-Builders.—Prof. E. T. Cox, having examined a great many specimens of potteries of the ancient mound-builders in the Western States, has never been able to find any evidence of their having been hardened by fire, or even sun-baked. The material employed is a mixture of river-mud and, most generally, pulverized mussel-shells, united in such proportions as to make a cement which hardens in the air, or on being exposed to moisture, like the concrete of the ancient Romans; hence this ancient "pottery" is in fact a sort of artificial stone. In chemical composition it agrees very closely with the concrete made of ordinary cement-stones. These facts lead to the conclusion that the art of manufacturing concrete, or artificial stone, did not originate solely with the ancient Romans, but that it was alike understood by the earliest inhabitants of America. As regards the mechanical processes followed by these ancient artisans, Prof. Cox says: "Though it is my opinion that the so-called pottery of the mound-builders was fashioned by hand, without the use of a lathe, yet I am convinced that the ancient pottery of Peru, and other South American states, was largely made of pieces formed by pressing the cement into moulds, and these pieces were subsequently united together to form the entire vessel. The lines of union are usually covered by a band, or some grotesque image. The numerous tubercles and other raised ornaments, which cover the surfaces of jugs, vases, etc., could only have been formed in this way. I do not, however, find any pottery of the mound-builders that would lead to the belief that their skill went so far as to enable them to mould it in parts, or to fashion it in any other way than by the hands."

A Primitive Fort.—One of the most remarkable works left by the mound-builders is a stone fort in Clarke County, Indiana. As described by Prof. E. T. Cox, this fort stands upon the terminal point of a high ridge, which is washed on its south side by the Ohio River, and on the north by Fourteen-Mile Creek. The point of the ridge is pear-shaped, and the fortification includes from eight to ten acres. The highest point at the stem of the pear is 280 feet above the Ohio, and is only 10 to 20 feet broad, presenting almost a perpendicular wall to the river. A natural wall of Niagara limestone furnishes complete protection against the approach of an enemy at the upper part of the fort, with the exception of a short gap on the creek-side, extending from the upper point southward for about 100 paces. This break in the natural wall is protected by an artificial wall 75 feet in height, made by laying up loose stone, mason-fashion, but without mortar. The base, for 65 feet in height, follows the slope of the hill-side, and then rises 10 feet vertically. Around the southern terminus of the point there is an artificial stone-wall 10 feet high, which connects the two natural walls of Niagara limestone, thus forming a complete barrier against attack. Inside the wall of masonry are numerous mounds of earth, and within the line of these mounds is a ditch 4 feet deep and 20 feet wide.

A Cheap Substitute for Bells.—Mr. J. A. Judson, C. E., writes us from Dutch Island, near Newport, that for several years past he has used a steel bar in place of a bell, with very satisfactory results. He caused a bar of steel about one inch and a half in diameter to be forged into an equilateral triangle of about three feet on a side, without uniting the two ends, thus forming an instrument similar in all respects except size to the rude musical appliance called the "triangle," used by negro minstrels and sometimes in brass bands. This is suspended from one of its angles by a rope attached to a simple wooden frame, and is struck by hand with an ordinary steel-faced blacksmith's hammer. A cord attached to the triangle and held in the left hand of the ringer prevents its whirling about when struck. If necessary, it may be permanently lashed, without materially interfering with the vibrations, and could then be rung by some stationary mechanical device. "I may have been fortunate," says Mr. Judson, "in finding an especially suitable bar of steel for the purpose, for it is certainly sonorous and powerful, answering all the purposes of an ordinary factory-bell, at merely the cost of so many pounds of steel, and a few hours of skilled labor."

Heat as a Disinfectant.—In the course of some experiments, made with a view to ascertain how far heat may be employed as a means of disinfecting articles of clothing, Dr. Ransom, of Nottingham, found that white wool, cotton, linen, silk and paper, may be heated to 250° Fahr. for three hours without apparent injury, although the wool shows a faint change of color, especially when new. The same may be said of dyed wools and printed cottons, and most dyed silks; but one kind of dyed silk easily turns brown by this heat, and pink silks of some kinds are also faded by it. The same temperature will, if continued for a longer period, slightly change the color of white wool, cotton, silk, paper, and unbleached linen, but will not otherwise injure them. A heat of 295°, continued about three hours, more decidedly singes white wool, and less so unbleached and white cotton and white silk, white paper, and linen both unbleached and white, but does not materially injure their appearance. The same heat, continued for about five hours, singes and injures the appearance of white wool and cotton, unbleached linen, white silk and paper, some colored fabrics of wool, or mixed wool and cotton, or mixed wool and silk. It is noteworthy that the singeing of any fabric depends not alone on the heat used, but also on the time during which it is exposed. In the experiment, the heat was obtained by burning gas with smokeless flame, and conducting the products of combustion, mixed with the heated air, by means of a short horizontal flue, into a cubical chamber through an aperture in its floor, and out of it by a smaller aperture in its roof. Fixed thermometers showed the temperature of the entering and outgoing currents, which represented the maximum and minimum temperatures of the chamber. A self-acting mercurial regulator maintained the temperature of the entering current at any required degree.

The Science of Education.—One of the most important papers read in the Section of Economic Science of the British Association was that by Mrs. Grey on the "Science of Education." The author complained that in Britain there is no adequate or general conception of what education is, and therefore of the magnitude and complexity of the facts on which a science of education, which can never be an exact, but only a mixed and applied science, must be based. We start with a confusion of terms, using education as synonymous with instruction; and the confusion of thought indicated by this misnomer runs through our whole treatment of the subject, theoretical and practical, and is shown in every discussion of the subject. It is surely time that this confusion should be replaced by a scientific conception of the process which should result in the most valuable of all products—human beings developed to the full extent of their natural capacity. What is wanted is, that teachers, like practical navigators, should be furnished with the principles of a science they have not had to discover for themselves, and with charts to guide their general course, leaving to their individual acumen the adaptations and modifications required by special circumstances. We have such knowledge to guide us in improving our breeds of cattle and our crops: must we remain without it in the infinitely more important business of improving our human crop, of getting out of our human soil all that it can be made to yield for social and individual good? Must every tyro still be allowed to try experiments, not *in corpore vili*, but on the most delicate and precious of materials—the human body and mind, on the most powerful of all forces—human passions and the human will; experiments in which success or failure means virtue or vice, happiness or misery, lives worthy or unworthy, sowing with every action a seed of good or ill, to reproduce itself in an endless series beyond all human ken?

NOTES.

During the summer, the division of the geological and geographical survey of the Territories under the charge of Prof. Powell explored Northeastern, Middle, and Southeastern Utah. In addition to the geographical and geological work, the expedition has collected, according to the *Tribune*, many interesting facts in ethnography. Prof. Powell has found several new ruins of ancient towns in the Colorado Valley, and has collected some specimens of ancient picture-writings, and many stone implements. Prof. Powell, we are told, is now prepared to indicate in his map the position of many scores of these ancient towns or hamlets now found in ruins in the valleys on each side of the Colorado.

Prof. Theodore Gill, of the Smithsonian Institution, and Dr. Elliott Coues, U. S. A., are engaged upon a systematic revision of the mammals of North America. The scientific competence of the authors, as well as their rare opportunities for the inspection of specimens in practically unlimited numbers, is an ample guarantee for the thoroughness of the promised treatise.

Dr. Lyon Playfair, at the recent meeting of the British Social Science Association, quoted Michelet's statement that, for 1,000 years, no one in Europe used the bath, and urged that it was no wonder that the epidemics of the middle ages cut off one-fourth of the population—no wonder that there were a spotted plague, black death, sweating sickness, dancing mania, mewing mania, biting mania, and other terrible epidemics.

In Sonoma County, California, according to the report of the Department of Agriculture, the farmers soak their seed-wheat from eight to twelve hours in a solution of sulphate of copper, in the proportion of six ounces of the salt to 100 pounds of wheat. In this way the "smut," which is a fungoid growth, is killed, and prevented from spreading from diseased to sound grains.

The council of a new college, recently opened in London for the medical education of women, includes the names of the following eminent physicians and physiologists, many of whom are also lecturers in the institution: Charlton Bastian, King, Chambers, Huxley, Hughlings-Jackson, W. L. Playfair, and Burdon-Sanderson.

About forty years ago the Government of France made a costly attempt to introduce the culture of the tea-plant into that country. Three thousand shrubs were imported and planted in various regions of France. Next year the disaster was complete. It is now known that the tea-plant does not give a crop unless with an average temperature reaching 61° Fahr., and a considerable atmospheric moisture in summer. The English Government have not been similarly deceived. Introduced on the slopes of the Himalayas at a height calculated for the suitable heat and moisture, tea now ranks among the sources of wealth of British India. With like success the cinchona is now cultivated in Asia; but botanists and meteorologists were first dispatched to the Andes to determine the conditions of its native growth.

De Candolle proposes a physiological classification of plants based on their relations to heat and moisture. He makes six divisions, viz.: megatherms, which need much heat and moisture; xerophiles, requiring dry heat; mesotherms, moderate heat; microtherms, natives of temperate climates; hekisotherms, natives of high latitudes; finally megistotherms, an exceptional group which require a mean annual temperature of over 30° C. (86° Fahr.).

A French botanist, Cosson, holds that lichens require a very pure air for their development; in fact, he thinks they afford a very delicate natural test of the purity of the atmosphere.

The Smithsonian Institution is soon to publish a memoir by Prof. Simon Newcomb, of the United States Naval Observatory, on "The General Integrals of Planetary Motion."

The French Government offers a prize of 300,000 francs for the discovery of an efficacious and economical means of destroying the *phylloxera* or of preventing its ravages. A commission, nominated by the Minister of Agriculture and Commerce, will determine the condition of compensation and the award of the prize.

Prof. Marsh is on his way back from his extraordinary expedition to the Mauvaises Terres of Colorado. A *Tribune* telegram, dated Fort Laramie, November 29th, says that the fossil-beds explored by the expedition are of the Miocene age, and rich beyond expectation. Nearly two tons of fossil-bones were collected, all belonging to tropical animals, some as large as elephants, others allied to the camel, rhinoceros, and horse.

Prof. Karl Koch has shown conclusively that China, and not Babylonia, is the home of the weeping-willow (*Salix Babylonica*). He describes, under the name *Salix elegantissima*, a new species of willow from Japan whose branches are even more markedly pendulous than those of the *Salix Babylonica*. One great advantage of this willow is, that it is not injured by insects.

In Montgomery, Alabama, according to a *Tribune* correspondent, the negroes form 69 per cent. of the population, yet of the 63 deaths in September, 53 were from the black population—in other words, 69 per cent. of the population furnishes 84 per cent. of the deaths. In October, the blacks furnished 73 per cent.

Prof. Mayer, of Stevens Institute, has invented an instrument for measuring the minutest possible variations of atmospheric pressure. A hollow metallic vessel, with unyielding walls, containing air, has adapted to it an open glass tube. In this tube is a short liquid column. The glass tube is in an horizontal position. The vessel is surrounded with melting ice, which keeps the air inside at a constant temperature. In this condition the liquid in the tube remains stationary if the atmospheric pressure outside remains constant; but any increase of pressure in the atmosphere will cause the liquid in the horizontal glass tube to move toward the vessel. The contrary motion takes place when the atmospheric pressure diminishes. These motions are registered continuously by photography.

Experiments made by Prof. Mayer show that solid cylinders of iron elongate on being magnetized, but contract to a corresponding degree in their transverse dimension, so that their volume remains constant. In hollow cylinders, on the other hand, the interior capacity is increased when they are magnetized.

No European grape-vine will thrive anywhere in the United States east of the Rocky Mountains. Prof. Planchon has written the history of the many efforts that have been at different times made to introduce into this country European vines, but the result has been failure in every case. Immigrants from France and Switzerland have repeatedly made the experiment in Kentucky, Indiana, Pennsylvania, Texas, Alabama, and Ohio; but everywhere the *phylloxera* has proved a deadly enemy. West of the Rocky Mountains the *phylloxera* does not occur, and hence California is filled with European vines.

The barbarous cruelties and needless wastefulness attending the seal-fishery, as now carried on, have received a check from the Newfoundland Legislature, which has passed a law preventing sealing-vessels from leaving port before a certain date, so as to give the seals at least another month after the breeding-season, in which the young may increase in size and value. The present practice is to kill the old seals indiscriminately, leaving the helpless young to perish by thousands. It is hoped that the governments of other countries will follow the example of Newfoundland.

Prestel, a German meteorologist, has observed a marked periodicity in the presence of ozone in the atmosphere. It is at its minimum at the end of September, increasing steadily, and reaching its maximum at the vernal equinox, after which it again diminishes.

A well-authenticated case of death from the sting of a hornet recently occurred in England. A woman was standing in the road near her house, when a hornet flew out from a nest near by and stung her on the right side of the neck. She fainted almost immediately, and expired in a few minutes.

A correspondent of the *Gardener's Chronicle* records a curious instance of the power possessed by the mycelium of mushrooms of penetrating bodies. One side of a mushroom-bed was of brick, four and a half inches thick, firmly set in hard lime, so close in the texture that it was impossible to introduce the point of a nail without considerable force. Nevertheless the mycelium found admission, and produced mushrooms of a considerable size on the other side. The wall, in several places, contained porous bricks and these too the mycelium found its way through.

In former times it was the custom for men of science, on making a discovery, and previous to publishing it in full, to put it in the shape of an anagram, so that in case some other investigator should make the same discovery later, and publish it, the anagram might show that the writer of it had the prior claim. At present, the usual custom is to send the discovery in a sealed packet to some academy. A correspondent of *Nature*, who signs himself "West," publishes a scientific discovery anagrammatically, as follows:

$$A^8C^3DE^{12}F^4GH^6I^6L^3M^3N^5O^6P$$
$$R^4S^5T^{14}U^6V^2WXY^2.$$

Now, who will be the first to find the key to this anagram?

A chemical examination of the air along the line of the London Underground Railway has shown that, when trains are frequent, the air is loaded with sulphurous-acid gas; and the authorities are now seeking a remedy for what has long been a serious annoyance to passengers.

The waters of the Great Salt Lake appear to be rising from year to year. The mountain-streams are steadily enlarging. The humidity of the atmosphere annually increases as the area of eultivation in the valleys becomes greater, and, as a consequence, the evaporation less. Tens of thousands of acres of farming, meadow, and pasture lands have been submerged along the eastern and western shores of the lake.

Frank Buckland, having eounted the eggs in a single sturgeon, found that they numbered 921,600. The total weight of the eggs was 45 pounds. In one ounce there were 1,280 eggs.

This being the season for Christmas-trees, attention is called to the faet that the use of red and green wax tapers is highly dangerous, owing to the poisonous nature of the coloring-matters employed. Analysis has shown the presenee in green tapers of arsenite of eopper (Scheele's green) to the extent of 0.60 per cent., and of sulphide of mercury (vermilion) in red tapers to the exteut of 1.93 per cent. Yellow and blue tapers, on the contrary, are pronounced harmless.

Dr. Cobbold states that cases of tapeworm are about twice as frequent among males as among females, the difference being explained, in his opinion, by the more cautious and fastidious habits of the female sex, as contrasted with males, in relation to the ingestion of underdone meat.

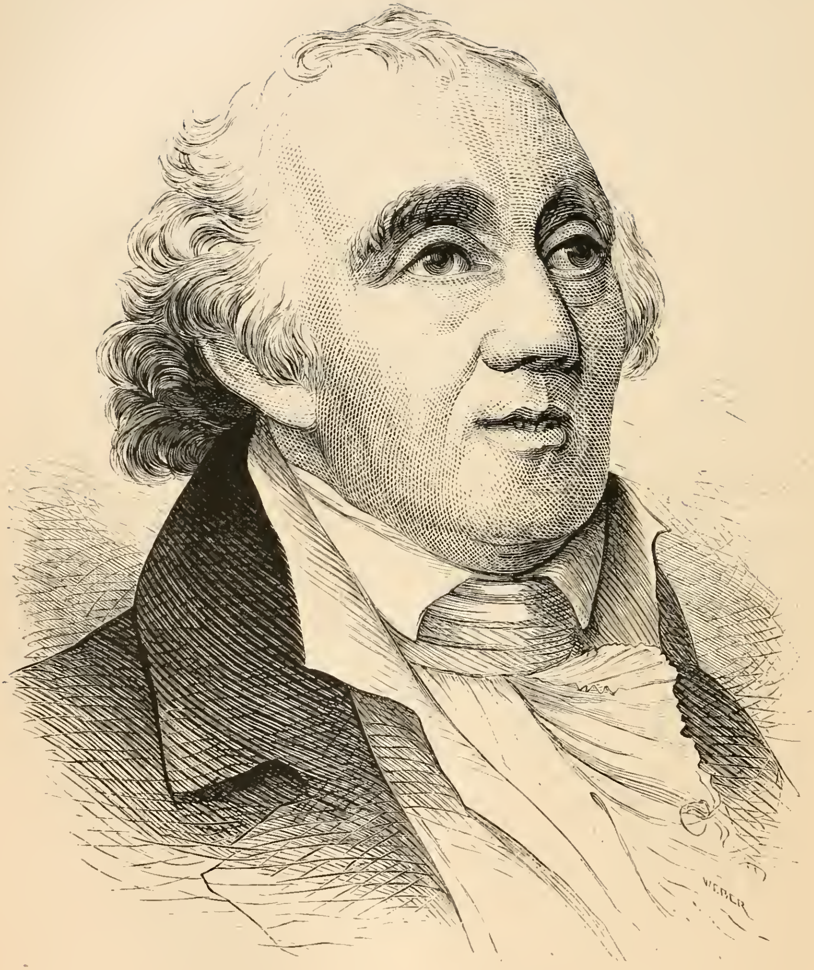
The disappearance of nitrogenous or organic matter from running water where exposed to the air is well known. Mr. A. Winter Blyth has lately shown that water running through closed iron pipes undergoes a similar process of purification, a remarkable difference being observed between the same water before and after it passes through the mains.

"Blue Gravel" is the name given to a rock underlying the gold-bearing alluvium of California and Nevada. Mr. E. Goldsmith, in a communication to the Philadelphia Academy of Sciences, says that this "gravel" is composed of two ingredients, widely differing in age, viz., of pebbles, and a lava by which they are cemented together. Some of these pebbles appear to be derived from slate rock and others from hornblend rock. The lava is extremely brittle. In hardness it is equal to apatite. A few grains of bright-yellow gold are found in it, but how they eame there it is not easy to say. Whether the gold eame from the pebbles, or was ejected from the volcano, it is impossible to decide.

Dr. John L. Le Conte calls attention to the dangers attending the use of Paris green for destroying noxious insects. It may so poison the soil as to prevent the growth of all vegetation. The National Academy of Sciences has adopted the following resolution on the subject: "That a committee be appointed to investigate and report upon the subject of the use of poisons applied to vegetables or otherwise for the destruction of deleterious insects and other animals, and also the incautious use of poisons in the ornamentation of articles of food, and for decorative purposes generally, such, for instance, as the coloring of paper."

Dr. Edward Smith, F. R. S., one of the most eminent physicians of England, died November 16th, aged fifty-six years. His researches on respiration and urea earned for him a fellowship in the Royal Society; his later researches were devoted to the investigation of the subject of dietetics. Dr. Smith experimented upon himself mostly, and thus subjeeted himself to many severe physical restraints in the interest of science. His published works are numerous, one of the latest being a volume on foods, in the "International Scientific Series."

Dr. Edwin Lankester, a voluminous writer on scientific subjects, and Fellow of the Royal Society, died at Margate, England, October 30th, aged sixty years. He began the study of medicine at University College, at the age of twenty, graduated at twenty-three; afterward studied botany under Lindley, and subsequently became lecturer on materia medica and botany at the St. George's School of Medicine. In 1844 he was elected secretary of the Ray Society; in 1845, was made Fellow of the Royal Society; and thereafter, to the end of his life, held successively positions of importance and trust in various scientific bodies, and as an officer of the state. His writings were chiefly on medical subjects and natural history, botany being his favorite branch of study.



FRANCIS HUBER.

(The blind naturalist, celebrated for his discoveries relating to bees.)

THE

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THE PERSONAL EQUATION.

By Prof. EDWARD S. HOLDEN,

OF THE UNITED STATES NAVAL OBSERVATORY, WASHINGTON, D. C.

IN an attempt to explain clearly some of the phenomena which have led to the consideration of what astronomers call the "personal equation," it will, perhaps, be most advantageous to consider the subject somewhat in an historical manner. In this way we shall, it is true, lose something in directness, but it will assist in gaining a definite conception of the whole subject if we consider it in the order in which astronomers have been forced to do.

To make the meaning of the term plain, it will be necessary to premise a brief account of the methods of observation with astronomical instruments, and of some of the refinements which have gradually been found necessary in these methods.

Nearly every astronomical observation has for an object to fix the *relative* position of two bodies *at a given time.* If, then, a second observation of a similar kind is made, these two, taken together, will suffice to give some idea of the apparent relative motion of one body, referred to the other. If, for example, the design is to determine the orbit of a new comet, the mode of proceeding is, or might be, something as follows: Some star, whose place is known (or whose place is subsequently determined), is chosen in the vicinity of the comet, and the distance of the comet from this star is measured. This may be done in several ways, by a sextant, with which we can measure this distance directly, or, more usually, by one of the fixed instruments of an observatory, with which we can determine two things: 1. The distance of the comet east or west of the star; and, 2. Its distance north or south of it. The distance north or south is usually determined by a direct measure of the celestial arc included between the respective parallels on which the star and comet are at a given time; while the distance east or west is usually measured by the interval of time required for the earth's rotation to carry a body from the meridian of the star to that of the comet. To make this measure, it is customary to fix in the focus of the telescope some uneven number of fine filaments of spider's-web at (say) equal distances apart, and to allow the telescope to remain fixed while the diurnal rotation of the earth carries the body first to be observed into the field of the telescope and slowly across this. As it crosses each of the threads, the time at which it is exactly on the thread is noted. Now, when the second body enters the field of the telescope (which is supposed to remain fixed in its former position) the times of *its* passage over the various threads are noted.

The mean of the times for the first body gives the time at which this body was on the middle thread (these being at equal intervals), while the mean of the times for the second body gives the corresponding time for the second body, and the difference of these two times gives evidently the distance which one of them is, east or west, of the other, expressed in *time*. This may be easily reduced to *degrees*, etc., by the rule that twenty-four hours is equal to 360 degrees.

If it were possible for an astronomer to note the *exact* instant of the *transit* of a star over a thread, it is plain that one thread would be sufficient; but, as all estimations of this time are, from the very nature of the case, but approximations, several threads are inserted in order that the accidental errors of estimations may be eliminated, as far as possible. The method of making these estimations will be better understood from the two following figures, 1 and 2. Fig. 1 represents

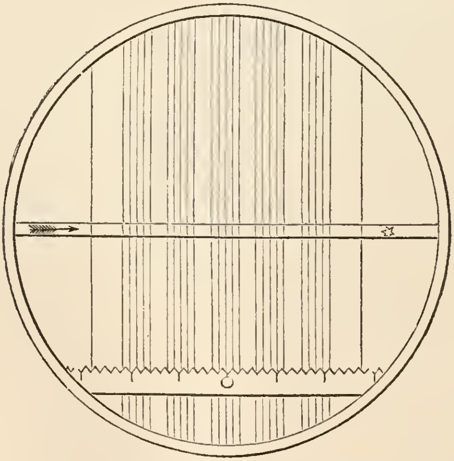


Fig. 1.—Transit-threads in Telescope.

the *reticle* of a transit-instrument as it would be viewed by an observer, where twenty-five threads are placed arranged in groups or *tallies* of five. The star may enter on the left hand in the figure, and may be supposed to cross each of these wires, the time of its transit over each of them, or over a sufficient number, being noted. The method of noting this time may be best understood by referring to Fig. 2.

Suppose that the line in the middle of the figure is *one* of the transit-threads, and that the star is passing from the right hand of the figure toward the left: if it is on this wire at an exact second by the clock (which is always near the observer, beating seconds audibly), this second must be written down as the time of the transit over this thread. As a rule, however, the transit cannot occur on the exact beat of the clock, but at the seventeenth second (for example) the star will be on the right of the wire, say at *a;* while, at the eighteenth second, it will have passed this wire and may be at *b*. If the distance of *a* from the wire is six-tenths of the distance *a b*, then the time of transit is to be recorded as — *hours* — *minutes* (to be taken from the clock-face), and seventeen and six-tenths *seconds;* and in this way the transit over each wire is observed. This is the method of "eye-and-ear" observation, the basis of such work as we have described, and it is so called from the part which both the eye and the ear play in the appreciation of intervals of time. The ear catches the beat of the clock, the eye fixes the place of the star at *a;* at the next beat of the clock the eye fixes the star at *b*, and subdivides the space *a b* into tenths, at the same time appreciating the ratio which the distance from the

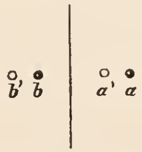


Fig. 2.—Passage of Star across the Thread.

thread to *a* bears to the distance *a b*. This is recorded as above. Now, if the action of the eye and the ear and the coördinating action of the brain (which must associate some spot in the field of view with some second) were all instantaneous in their action, the phenomenon of personal equation would not exist. As a matter of fact, when the clock beats and the star is really at *a*, the mind refers it to some point farther on in the field as *a′;* and when the clock again beats, the star, which truly is at *b*, is by the mind referred to a point *b′*. The distance *a b* is the same as *a′ b′;* but the distance from the thread to *a* is greater than the distance from the thread to *a′*. Hence, instead of recording the time of transit as $17^s.6$, an observer, whose habit is correctly represented by the figure, might record this time as $17^s.4$, and the correction $+ 0^s.2$ would be required to be applied to his times of transit to reduce them to the exact truth: $+ 0^s.2$ is then his *absolute* personal correction. But, in general, we have no means of determining where *a* and *b*, in our field of view, are, and hence the knowledge of the *absolute* personal equation has to be gained by some special devices, to be hereafter spoken of. A little consideration will show, however, that, although every transit observed by our astronomer is too early by $0^s.2$, yet, in ordinary cases, this correction is of no account, provided only that it is constant. If he observes the star too early by $0^s.2$, and the comet also too early by that amount, the *difference* in the times will be *absolutely* correct. But suppose one observer to note the transit of the star, and another that of the comet: each may have a peculiar habit, so that where one would note $0^s.2$ too early, another might note $0^s.3$ too early, and the difference of their *absolute* personal equations, $0^s.1$, it would be necessary to apply to the observations of A to reduce them to homogeneousness with those of B. This difference of *absolute* personal equations is *relative* personal equation, which, when once truly known, enables us to reduce the observations of one skillful astronomer to what they would have been had another made them.

We say "skillful," because it is only among skillful observers that the phenomenon in question is truly found. In astronomical observations the senses are trained to a fine delicacy, and old observers acquire a constancy of habit which gives to their work a homogeneousness that is wanting in that of younger men.

We have given a brief account of the early method of estimating the time of a star's *transit* across a spider-line in the field of the telescope by the method of *eye and ear;* there is yet another method now in common use, which it is necessary to understand before we pass to the consideration of the means of determining personal equation.

This second method is the American or chronographic method; this consists, in the present practice, in the use of a sheet of paper wound about and fastened to an horizontal cylindrical barrel, which is caused to revolve by machinery once in one minute of time. A pen of glass which will make a continuous line is allowed to rest on the paper, and to this pen a continuous motion of translation in the direction of the length of the cylinder is given. Now, if the pen is allowed to mark, it is evident that it will trace on the paper an endless spiral line. An electric current is caused to run through the observing clock, through the pen, and through a key which is held in the observer's hand.

A simple device enables the clock every second to give a slight lateral motion to the pen, which lasts about a thirtieth of a second. Thus every second is automatically marked by the clock on the chronograph-paper. The observer also has the power to make a signal (easily distinguished from the clock-signal by its different length), which is likewise permanently registered on the sheet. In this way, after the chronograph is in motion, the observer has merely to notice the instant at which the star is *on* the thread, and to press the key at that moment. At any subsequent time he must mark some hour,

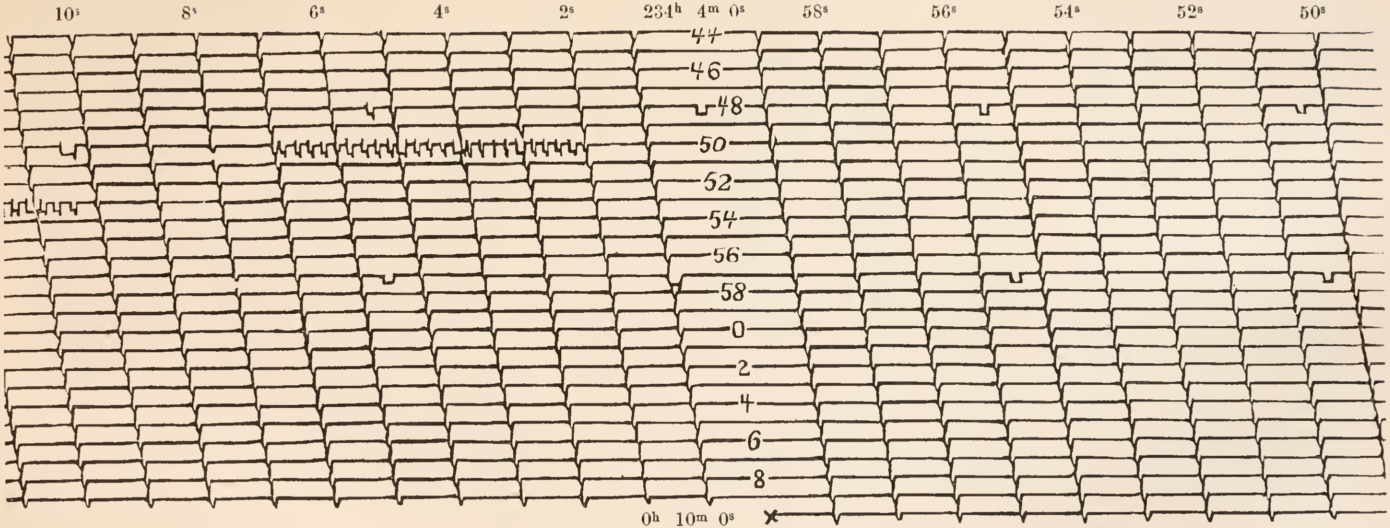


FIG. 3.—PORTION OF A CHRONOGRAPHIC RECORD.

The upper line of figures numbers the seconds; and as twenty of them are shown, and the cylinder revolves once in sixty seconds, about one-third of the length of the strip of paper is here represented. The middle column of figures numbers the lines, and, therefore, the minutes. The jogs in the lines are repeated so exactly at intervals of one second as to give the effect of columns across the paper. As explained in the text, it is all done by one pen, which makes one continuous line round and round, the machine making the regular jogs as a time-scale, and the observer making the irregular jogs at the instant the star reaches the thread; its time being thus exactly recorded.—[ED.

minute, and second, taken from the clock on the sheet at its appropriate place, and the translation of the spaces on the sheet into times may be done at leisure. This will be plainer if we examine Fig. 3, which is a fac-simile of a portion of a chronographic record.

The marks of the clock giving regular signals of seconds are easily distinguished; the rattles were made by the observer to attract attention to an observation to follow: and the signals of the observer are seen at the times of the transits of various stars. By applying a graduated ruler to the sheet when it is unrolled, the exact times of transit can be determined to within a hundredth part of a second, provided we have some hour, minute, and second marked on the sheet as an origin of time.

It is quite plain that the senses of the observer are not strained to so great a degree in this method as in the method of eye and ear; the eye has but one thing to do, the ear is not occupied, and the hand has only to press the key at the proper time.

In this method, we see that the origin of relative personal equation is again in the different times required for different observers to co-ordinate the position of the star in the field and the position of the wire.

True personal equation, considered physiologically, must arise from the personal differences between observers when they note the *same* phenomenon. With the chronograph it is the habit of most observers to tap the observing key at the moment at which the star is actually *on* the wire. There are cases, however, where astronomers of some experience are accustomed to tap the key so that the sound of the tap shall come to the ear at the time when the star is on the wire. This seems an utterly wrong habit of observing, as it is really the record of an event which has not yet taken place which such an observer makes. Astronomically, the difference between such an observer and another observer may be treated as a case of personal equation, provided the habit described above remains constant, which it is probably less likely to do than the ordinary one.

The first case of personal equation on record appears in the "Observations" of the Rev. Nevil Maskelyne, Astronomer Royal for England ("Observations" for 1796, vol. iii., p. 339). We there find the following note: "I think it necessary to mention that my assistant, Mr. David Kinnebrook, who had observed the transits of the stars and planets very well in agreement with me all the year 1794, and for a great part of the present year, began from the beginning of August last to set them down half a second of time later than he should do according to my observations; and, in January of the succeeding year, 1796, he increased his error to eight-tenths of a second. As he had unfortunately continued a considerable time in this error before I noticed it, and did not seem to me likely ever to get over it and return to a right method of observing, therefore, though with reluctance, as he was a diligent and useful assistant to me in other respects, I parted with him."

But time has its revenges, and Kinnebrook's observations are now used as well as Maskelyne's (*see* "Annales de l'Observatoire de Paris; Memoires," iii., p. 307), and they are probably about as free from accidental errors as his.

In 1822 Bessel examined this subject, and we find in the Königsberg observations of that year an account of quite extended experiments on personal equation.

Bessel, after quoting from Maskelyne's own report (see extract above), considers the subject at some length. He calls attention to the fact that the accidental errors in an eye-and-ear observation certainly do not exceed two-tenths of a second, and that a careful consideration of the observations of Maskelyne and his assistant shows that there may be an "involuntary constant difference" between the estimations of various observers which far surpasses the limits of possible accidental error.

In 1819 Bessel made a visit to the Seeberg Observatory, where he observed, on two nights, transits with Von Lindenau and Encke. These observations showed no personal equation between these three celebrated astronomers. In 1820 Dr. Walbeck and Bessel made several sets of observations at Königsberg, for the purpose of determining their relative personal equation, and the results of their work are given below:

			s.
1820, December	16th and 17th,	Walbeck later than Bessel	1.045
"	17th and 19th,	" " " "	0.985
"	19th and 20th,	" " " "	1.010
"	20th and 22d,	" " " "	1.025
		Mean	1.041

Bessel says that this great difference was evident from the second day, and that no pains was spared by either of them to observe carefully; and that at the end of the series each was confident that it would have been impossible for him to observe differently, by so much even as a tenth of a second. Here, then, was an enormous difference—one almost incredible. To test the reality of the phenomenon, Bessel compared with Argelander, and found that Argelander was later than he by $1^s.223$.

Bessel remarks that neither Walbeck nor Argelander had observed as much as he had with the transit-instrument, and he therefore used all opportunities for comparing his work with that of Struve, of Dorpat. He found that in 1814 Struve was later than himself by $0^s.044$; in 1821, by $0^s.799$; in 1823, by $1^s.021$. Bessel now determined to arrive at some conclusion by studying this phenomenon under different aspects.

To this end Argelander and himself noted the times of 78 disappearances or reappearances of a material object, and he found that Argelander was later than himself by $0^s.222$. Again, in the observation of the occultations of stars (an instantaneous phenomenon), Argelander was slower than Bessel by $0^s.281$. Here was some light: for it was now evident that not only had each astronomer a different habit of estimating time, but that this habit was only constant so long as the same phenomenon was observed; that a personal equation for transit observations would not serve for observations of occultations.

Bessel next investigated the question whether there was any difference in his own absolute personal equation in observations with a clock beating whole seconds, or with a chronometer beating half-seconds; he found that he observed $0^s.494$ *later* when the clock beat half-seconds than when it beat whole seconds, while Argelander and Struve did not change their habits in this regard.

Bessel's whole investigation is very complete, especially when we consider that it was the first published research on a subject which had escaped attention until his time. The principal points established were:

1. A personal equation subsists in general between two observers.
2. For limited periods of time this equation is probably constant between two observers for the same class of work.
3. The absolute personal equation of any one observer varies with the class of observation; i. e., from transit observations to sudden phenomena like occultations.
4. The rapidity with which the star (in transit observations) traversed the field of the telescope had no influence on Bessel's personal equation.

Bessel does not seem to have supposed that there would be any different personal equation for stars and for the moon. This we now know to have been erroneous, and we shall see that the apparent velocity with which a star moves through the field of the telescope is also held by some observers to have an influence on the magnitude of their personal equation.

All of the preceding results referred simply to the personal equation between observers who were using the eye-and-ear method. As soon as the chronographic method of registering transits was introduced, it was seen that the personal equation became smaller. This is undoubtedly due to the smaller amount of work which the brain has to perform; the phenomena to be appreciated are, in this latter case, far more simple than in the former, and the effect of this is shown in the amount of personal difference.

We must now give a brief account of the ordinary methods for determining the amount of the relative personal equations of various observers, in order that we may proceed to the determination of the absolute equation, which is of great interest physiologically and psychologically, although not of capital importance to astronomy. As we have seen, to reduce the observations of A to what they would have been if B had made them, it is simply necessary to know how much later B is in the habit of observing than A, and to apply this as a constant correction to A's work.

This may be done in practice by A and B observing the same star in the same telescope; A over the first ten wires (*see* Fig. 1), and B over the second ten.

A knowledge of the distances of the various wires from the middle wire enables us to compare A's work with B's, and A—B is the relative personal equation.

There is, however, a strong objection to this process: if personal equation is any thing, it is the difference between established *habits;* and, if A observes over ten wires, and then hastily rises to allow B to take his place at the instrument, both A's habits and B's are broken in upon, and the resulting personal equation is likely to be affected by this fact. In general, the way adopted is to allow A to observe several stars leisurely, and from them to determine the error of the clock; B does the same, and from his observations also a clock-error is found; the difference of these clock-errors, reduced to the same epoch, gives the relative equation of A and B.

Now if, instead of A registering his own observations on the chronograph (for example), we could have the star register its own transit, then B's observation, compared with this, would give at once an absolute equation. We cannot use the real star for this purpose; but several attempts have been made to construct an apparatus which should register the transit of an artificial star, which star could, at the same time, be observed. The principle of all of these machines is, in general, the same, and we will merely give a brief account of one which is now under trial by the Coast Survey.

The artificial star is produced by lamp-light falling upon a small hole in a blackened plate; this plate is given a motion laterally, and the small point of light passes from one side to the other of a plate of ground glass, upon which lines are ruled to represent the spider-lines of the *reticle.* As the artificial star passes each wire, an electric signal is recorded on the chronograph, and the observer can also record his signal; and thus on the same chronograph-sheet many observations of absolute personal equation can be permanently recorded. Any velocity can be given to the star, so that it may pass through the field of view as slowly as the pole-star, or as rapidly as a star at the equator.[1]

[1] The chief objection to this apparatus is, that there is a constant error in its indications; i. e., it can never be adjusted so as to give its signal at the exact moment of transit, but it is always too soon or too late. This is sought to be eliminated by allowing the artificial star to travel first from right to left, and then from left to right, and using the *mean* of the two determinations. It is still a question whether the *observer's* habit is the same no matter which way the star is moving.

An apparatus similar to this was invented and used by Wolf, of the Paris Observatory, and we owe to him much the fullest account of personal equation which we have. We cannot do better than to give a brief abstract of his memoir ("Mémoires de l'Observatoir e de Paris," tome viii., p. 153), as the results obtained by the American device have not been made public.

His first experiences showed him that his absolute personal equation, when he used the chronographic method of recording, was extremely small (from *three* to *four* hundredths of one second); and, although this was an interesting fact, yet the very smallness of this equation showed that it was hopeless to attempt to discover the *laws of variation* of so minute a quantity.

These laws would be masked by the accidental errors: so that all the observations of M. Wolf have been by eye and ear. It should be stated that M. Wolf is an observer of experience. In his own experiments he proposed to himself to determine the effect on his equation—

(*a.*) Of the position of the observer (sitting or standing, etc.).

(*b.*) Of the magnifying power of the telescope.

(*c.*) Of the direction of motion of the star (i. e., whether from right to left, or the reverse).

(*d.*) Of the brightness of the star.

His personal equation he found was, at first, about $+0^s.3$; and in a short time this fell to $+0^s.1$; this was undoubtedly due to the fact that the observer felt in what direction his observations had to be modified, in order to bring them nearer to the truth, and that he unconsciously so modified them. This, however, did not continue without limit; his personal equation remained, for all the time he observed, at this lower limit, and this fact gave him the first clew to the physiological explanation of the phenomenon.

M. Wolf finds that the brilliancy of the star has no sensible effect on personal equation, a conclusion identical with that derived by Mr. Dunkin, of the Royal Observatory at Greenwich ("Monthly Notices, Royal Astronomical Society," vol. xxiv., p. 158).

With regard to the influence of the direction of motion of the artificial star, M. Wolf finds in his own case a mean constant difference of $0^s.04$ obtained from over 400 transits: this he subsequently explains by the fact that, if his right eye be fixed on two dots equidistant from a line drawn on a sheet of paper, one of these dots always appears nearer to the line than the other by a small quantity. This, of course, is a defect in the symmetry of the eye, and it is quite a common defect, which probably many of the readers of The Popular Science Monthly have, perhaps without knowing it.

The influence of the apparent velocity of the star Bessel states to have been nothing in his own case, provided the star was situated more than 20° from the pole. Wolf's experiments do not agree with this, and he confirms the researches of Dr. Pape and of Dunkin.

Pape finds (*Astronomische Nachrichten*, vol. xliv., p. 179) that the error of a transit observation is composed of two parts: one is constant, and the other depends on the polar distance of the star. Dunkin likewise considers the probable error of a transit observation as depending upon the polar distance of the star, and Wolf's experiments corroborate these results, and show that his own personal equation became larger as the velocity of the star increased. It is evident that this rule must be held true only within limits, and probably these limits are not very far apart. Wolf further made experiments to determine whether the position of the observer affected his personal equation, and he concluded that, for his own case, there was no effect due to this cause. It is probable that most astronomers would differ with Wolf in this respect: observers of double stars, especially, have noticed a constant influence in their measures due to the position of the head.

After having recited the results of his experiments, M. Wolf comes to the consideration of the really important question, "What is the origin of the phenomenon known as personal equation?" Before he discusses this, he considers the remarkable personal differences between Bessel and other astronomers which we have noticed, showing that this is undoubtedly the largest personal equation on record, and expressing his opinion that it was really due to an erroneous counting of the whole seconds, and that the fractional part of his enormous personal equation with Argelander ($1^s.223$) was alone a case of true physiological personal difference. Let us recall the fact that Bessel and Argelander differed in observations of sudden phenomena only by $0^s.222$, or $0^s.281$; and again, that Bessel observed transits with a chronometer beating half-seconds so much as $0^s.494$ (nearly a whole beat) later than with a clock beating seconds; and it seems impossible to avoid Wolf's conclusion that Bessel counted his seconds differently from other observers. The only thing which militates against this theory is, that Bessel must have examined this question of enumeration himself; and again, that, in two nights' observation with Von Lindenau and Encke, he found no signs of personal equation. Encke, however, in speaking of this large personal equation of Bessel's, says that there is no doubt that he had a different method of counting the strokes of the clock from other observers. M. Wolf, too, mentions the case of an assistant at the Paris Observatory, whose transit observations were earlier by one second than those observed by his fellow-assistants (Bessel's habit), but, in this case, a few experiments on artificial transits sufficed to show him that his habit was wrong, and led him to change it.

The opinion of most astronomers has been, that personal equation is not purely a physiological phenomenon, but likewise a psychological. The time required for the sound of the clock to reach the observer's brain, and the time required for the light to pass from the image of the star, so as to excite the nerves of vision, are both very small: it is the coördinating power of the brain that works slowly—and absolute personal equation is largely the measure of the time required for the brain to superpose two different sensations, to coördinate impressions derived from different sets of nerves.

This view M. Wolf combats, and maintains, on the contrary, that the phenomenon in question is purely physiological, and arises from the duration of the luminous impression of the image of the star on the retina. To prove this, he has applied his apparatus to the observing of transits in which the seconds of the clock were not marked by audible beats, but by flashes of light appearing in the field of the telescope.

In this case, and also in the case where the seconds of the clock were not heard, but were marked by light taps on his hand, his equation remained almost constant (*see* table):

The second marked by sound,	$: \varepsilon = +\ 0^s.10$	80	observations.
" " " " sight,	$: \varepsilon = +\ 0.08$	80	"
The second marked by sound,	$: \varepsilon = +\ 0^s.11$	80	"
" " " " feeling,	$: \varepsilon = +\ 0.11$	80	"

This table seems to bear out M. Wolf's view; but, in this connection, it will be interesting to refer to a paper by Mr. T. C. Mendenhall, of Columbus, which appeared in the *American Journal of Science*, vol. ii., p. 157. This gentleman says: "An attempt was made to determine the relative rapidity with which responses are made to impressions made upon the different senses. . . . Time is measured on a register similar to the astronomical chronograph, in which I have been able to move a slip of paper with great regularity at the rate of about one and one-half inch per second, the seconds being registered upon the slip by a seconds pendulum according to the electric method. The person on whom the experiment is being made is seated at a table, having his hand on a key; by pressing this, the time of the action is registered on the paper. I made an apparatus, by means of which the circuit is completed for an instant the moment that there appears at a circular opening, about three-fourths of an inch in diameter, a card, red or white, as I choose, which completely fills the opening. The subject is instructed to watch this opening, and to press the key immediately on seeing the card. The actual appearance of the card and his closing the circuit in response are marked on the slip of paper by two dots about one-fifth of an inch apart (two-fifteenths of a second). This is a measure of the time occupied by the somewhat complex operation of his perceiving the object, and acting in response to that perception. I introduce the exercise of judgment by giving him two keys, one for each hand, and by instructing him that, when a white card appears, he is to close with his right hand, and when a red card appears, with his left. . . . According to the same general plan, I made trials concerning the sense of hearing. I arranged that, by pressing upon the key, unseen by the subject, I could at the same time close the circuit and produce a clear and distinct sound, upon hearing which he made a response registered as before. I connected my apparatus with the key-board of a piano-forte in such a way that I was able to introduce an exercise of judgment in the comparison of two tones differing in pitch much or little, as I chose. . . . With different persons, as many as 2,000 individual trials have been made, and the errors of experiment eliminated as far as possible by averages. . . . As was anticipated, different individuals furnished, in some cases, strikingly different results, but, in general, they all followed the order given in the table:"

CASE OF A. G. F.	Time in seconds.
Response to appearance of a white card	0.292
" " " " an electric spark (in the dark)	.203
" " sound	.138
" " touch on the forehead	.107
" " " " " hand	.117
" when required to decide between white and red	.443
" " " " " " tones C and E	.335
" " " " " " C and C above (octave)	.428

One cannot but be struck with the additional time required when the phenomenon to be observed becomes even slightly more complex. This is evidently not entirely a physiological effect, but is truly psychological in part. Just what bearing this has on the question of the cause of personal equation it would be difficult to say: at the same time we must admit that the slightest additional exercise of judgment requires additional time. This is forcibly shown by the smallness of chronographic personal equation as compared to eye-and-ear-equation.

Let us now consider personal equation in things other than the estimation of time. We stated that the distance of one star, north or south of another, was usually measured directly; i. e., by graduated circles for large distances, and with micrometers for small ones. Prof. Coffin, now Superintendent of the American Ephemeris, has shown that in his own case, and in the case of two other observers, at the United States Naval Observatory of Washington, a marked personal difference appears in the observations of *a* Lyræ, and one or two other stars which pass near the zenith of Washington, *depending on the direction in which the observer faced*, whether north or south. It is plain that a star near the zenith may be observed as a south star or as a north star, and it appears that each position gives a different polar distance to the star: the difference of polar distance is small but constant.

In reading microscopes, and, in short, in performing any operation where the senses are strained to appreciate small differences of time, space, or position, and particularly where the judgment has to be exercised, personal differences are present. In general, these are constant with the same observer, and in astronomy they are usually eliminated in the determination of the zeros. For example, if an observer reads the microscopes of a Transit Circle habitually too large, when he is determining the zenith-distance of a star, it is likewise his habit to read them too large when determining the position of the zenith-point from which zenith-distances are counted; and the resulting quantity is likely to be free from all but accidental errors.

Occasionally there arise cases where these differences (in the same observer) are not eliminated, but multiplied.

In the measurement of a base-line, for example, the various rods are brought into contact under a microscope: if an observer judges these rods to be in contact when they are not, it is evident that his error, originally small, will augment with the number of contacts, and it may become serious.

In the comparison of the national standards of length, undertaken by the English Ordnance Survey, an annoying case of personal difference was found.

These comparisons were made by bringing a movable cross of spider-lines to bisect one of the lines engraved on the various bars, and it was found that Captain Clarke, R. E., and Quartermaster Steel, R. E., who made the greater number of comparisons, differed in their estimation of a bisection by a constant amount which was annoyingly large: so that "the probable error of the final results is nearly double what might be expected from errors of observations only." This error cannot be eliminated, and it still remains in the published results.

We must constantly bear in mind that the quantities of which we have all along been speaking are extremely small, and that in fact they are masked by accidental errors for inexperienced observers in most cases. Still they exist, and they are among the most curious of phenomena: their careful study would well repay physiologists.

We can never be sure we have eliminated them so long as the human mind or body is a part of the machine by means of which we are comparing or registering events; and, just so long as mind or body is employed, we can be sure that personal differences will not only exist, but that they will vary from day to day. We must use for eliminating personality those values which are the best attainable, and assume these values to be constant over extended periods of time —weeks or months. In astronomy of precision, however, we have other errors to fear much more variable than personal equation, and it is to the elimination of these that attention should be directed. In other branches of research less exact in method, personality becomes of more importance, and an attentive consideration of its effects may be well worth while undertaking.[1]

[1] The writer has recently had occasion to examine drawings of the same nebula by different observers, with telescopes which are quite similar, and the enormous differences which exist in the representations show personal differences of the most marked kind, for nothing is more certain than that all the changes shown by the drawings have not taken place.

BACTERIA AND THEIR EFFECTS.

By L. A. STIMSON, A.M., M.D.

LIVING organisms, microscopical in size, of the simplest, most elementary nature, and moving freely in different liquids, have been known to observers for nearly two hundred years. Scientific classification and description were long impossible, on account of the meagre facilities furnished by the microscopes of the last century; but, during the last fifty years, the means of observation have been so much improved, and the number of observers has been so great, that the advance in our knowledge of microscopical bodies compares favorably with that in other branches of science. This advance has been greatly stimulated by a tendency to see in low vegetable or animal organisms the exciting cause not only of fermentation and decomposition, but also of many diseases. Pasteur's researches into the nature and causes of fermentation, the lectures and publications of Tyndall and Huxley, and the bitter discussions about spontaneous generation, have made us all familiar with the names *bacteria*, *vibriones*, and *micrococci*, or *microzymas*, with which we associate the idea of microscopi-

FIG. 1.—*a*, Micrococci; *d*, Micrococci, multiplying by scission: *b*, *c*, Bacteria (rod Bacteria, B. termo; *e*, vibriones; *f*, *h*, *i*, *k*, Torulæ, or Yeast-Plant, sprouting; *g*, probably "Dauersporen," durable or resting spores.

cal bodies, round, oval, or rod-like and jointed, varying in length from five ten-thousandths to one one-hundredth of a millimetre, and found especially in putrefying vegetable and animal infusions. The term *micrococcus* has always been restricted to the small, round, or ovoid bodies, but *bacterium* and *vibrio* have been applied indiscriminately to all, the former being more commonly used in France and Germany, the latter in England. When used in the narrower sense, *bacteria* denotes stiff, rod-like bodies, single or jointed, motionless or endowed with an oscillatory movement in place, while *vibrio* is applied to those which move rapidly across the field of the microscope with an undulatory, sinuous motion. Another variety, less frequently found, is larger, and has the form of a corkscrew, with from one and one-half to three or even four complete turns. These spiral forms are perfectly rigid, and rotate about their long axis with great rapidity, moving rapidly forward and backward with the regularity, although not the deliberation, of a pendulum. Their rotation about the long axis gives rise to the appearance of a wavy, serpent-like motion, which has deceived many observers, and it is very probable that the smaller vibriones mentioned above owe their apparent sinuous motion to the same cause. The ease with which one may be deceived on such a point will be readily understood by any one who has noticed a large screw in motion, or the shadow of a slowly-turning corkscrew.

Leeuwenhoek, a Dutchman, published, in 1684, the earliest observations of bacteria of which we have any record. He found them chiefly in the matter picked from between his own teeth and those of his acquaintances, and, animated apparently by the same spirit for which his countrywomen are so noted, he defends himself against a possible charge of uncleanliness by mentioning that he habitually brushed his teeth after every meal; but he also records that he found the largest quantity of bacteria between the uncared-for, broken teeth of an old man. He supposed these bacteria to be animals, and, indeed, gave the name *eels* to some large ones which he found in vinegar, whose motions were so active that he was "obliged to kill one before the limner could portray it." In the eighteenth century Müller made a classification of the forms then known, but it was not until after the great improvements made in the construction of microscopes, about 1820, that Ehrenberg gave the complete description and classification which have served almost until the present day. His book ("Infusionsthierchen") was published in 1838. The different forms were grouped in one family, the *Vibrionidæ*, and, as the title shows, were still supposed to be animals.

To-day they are known to be plants, and the different varieties are supposed by many observers to represent only different periods of development. Robin asserted several years ago that the ordinary rod bacteria could develop into the long thread bacteria, and even into the long filaments of leptothrix found so constantly in the mouth; but this was not generally believed, and the latest complete classification, that of Ferd. Cohn, published in 1872, is based upon the absence of such a developmental relationship. The study of these plants is rendered very difficult by their extreme smallness, and all attempts to cultivate them under the microscope, in "wet chambers," have failed to disclose the secrets of their growth, on account of the abnormal conditions in which they are necessarily placed. A considerable depth of liquid seems to be essential, as do also the presence of air, and protection against shocks or jars, and movement of the liquid; consequently, they can be studied only by comparing the forms found at intervals during a long period of time, either when cultivated artificially, or when growing spontaneously under natural conditions.

In this way Billroth, who has published the most recent and, in many respects, the most remarkable work upon the subject, was able to make out the whole series of changes, from the spore to the long filaments, by using for his observations the yellowish mould which formed on the wall of his laboratory, where the water leaked slowly from a loose faucet. At the same time he discovered the nature and importance of certain glistening spherical bodies frequently found in infusions containing bacteria, and called *Dauersporen*, or durable spores (Fig. 1, *g*), by Cohn, although he did not think bacteria were developed from them. Billroth demonstrated that these *Dauersporen*

FIG. 2.—BACTERIA AND LEPTOTHRIX FILAMENTS FOUND IN A TURNIP-INFUSION.

form micrococci in their interior, which are set free by the bursting of the envelope, and are then capable of multiplication by scission, or of lengthening into bacteria; also, that they are endowed with great vitality, and are not destroyed by freezing, boiling, or drying. He had some which germinated after they had been kept dry for eight years; and, whenever he wished to make sure of the destruction of the spores contained in his experimental liquids, he heated them to 392° Fahr.

They are formed in the interior of bacteria, and sink to the bottom of the liquid which contains them. The importance of these facts in their bearing upon the question of spontaneous generation, and upon the innumerable repetitions and variations of the experiments with sealed flasks, which have attracted so much attention since Pasteur made them, cannot be over-estimated; for, as Prof. Wyman, of Cambridge, says, "The issue between the advocates and opponents of the doctrine in question" (spontaneous generation) "clearly turns on the extent to which it can be proved that living beings resist the action of water at a high temperature."—*American Journal of Science and Art, September*, 1867.

Bacteria themselves are much more easily affected by heat and cold than are these *Dauersporen*. Their motions cease when the temperature is reduced nearly to the freezing-point; but it may be carried even below zero, and yet the movements will recommence as soon as it is raised again above 40° or 45°. Exposure to a temperature of 140° will kill them; but this result seems to depend quite as much upon the length of time during which they are exposed to it, as upon the degree of heat itself, several hours being required for the lesser degrees, while ten to fifteen minutes, at boiling heat, are sufficient, and even four or five at 215°.

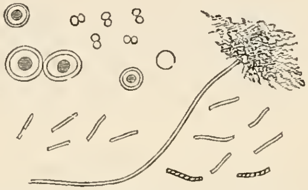


Fig. 3.—Bacteria, Leptothrix, and Spore-like Bodies found in a Solution of Ammonic Carbonate and Sodic Phosphate.—The tuft at the end of the filament of Leptothrix is probably an accidental accumulation of fragments.

In the air, bacteria, or bacteria-spores, exist, but only in moderate numbers, for exposure to the air often fails to cause cloudiness of artificial nutritive liquids, when the plants that existed in them beforehand have been destroyed by heat; and sometimes portions of meat taken from a recently-killed animal, with all possible precautions to prevent inoculation with bacteria through the instruments employed, and placed in open vases that have been washed in alcohol and then scorched in a hot flame, remain for days and weeks without putrefying. They are present in all kinds of water, and generally in considerable numbers. Cohn found them in the vapor condensed upon the inner surface of a bell-glass placed over a dish of water; and it is probable that those found in the air are enabled to live by the moisture contained in it. Their presence in the liquids and tissues of the body, often affirmed and denied, is now proved beyond question, Billroth's experiments on this point having been repeated and confirmed very recently by Tiegel. Rapid multiplication in the living body is prevented in part by the motion of the blood, and in part by the vital energy of the tissues, which is so vigorous that these plants cannot check it, and thereby obtain the nourishment needed for their own growth; but, when life has ceased, or when an abnormal condition of the tissues has been brought about by any cause, then rapid growth begins, and we have, in the one case, putrefaction; in the other, various pathological changes of more or less importance.

About the year 1865, two physicians of Strasburg, Messrs. Coze and Feltz, published a series of experiments which they had made with inoculations of putrid matter; and in 1872 they published a book upon the same subject, claiming that the virulent effects of putrid matter were due to the presence and growth of bacteria, and that the blood of an animal poisoned with such matter was itself virulent to a high degree, and that this virulence was increased by successive inoculations. A similar series of investigations had led another French physician, Davaine, to the opinion that the disease called anthrax, when it occurs in animals, and malignant pustule when it affects man, was caused by a certain variety of bacteria, to which he gave the name *bacteridia.*

Davaine repeated the experiments of Coze and Feltz, and in September, 1872, read before the *Académie des Sciences*, in Paris, a report of three series of inoculations with putrid blood, the results of which were so startling that for several months the discussions in the Academy turned almost exclusively upon the subject of septicæmia, or blood-poisoning. The first series showed that inoculation of a rabbit with a drop of blood, putrefied in the open air, rarely killed the animal, and that sometimes ten or fifteen drops were necessary. The second series comprised successive inoculations of blood from one septicæmic animal to the next, and showed that $\frac{1}{10}$ to $\frac{1}{100}$ of a drop was sufficient to kill the fifth, $\frac{1}{10000}$ to $\frac{1}{20000}$ would kill the tenth, while, for the twenty-fifth, the one-ten-trillionth part of a drop was fatal.

Incredible as some of these assertions seemed, they were verified by many experimenters; but the minimum dose that would certainly kill was placed at the one-millionth part of a drop. Davaine claimed that the active poisonous principle was the bacterium, which, by its growth and multiplication in the blood, acted as a ferment; and this opinion, supported by Pasteur, was generally accepted, and it was supposed that the ordinary acute inflammatory complications of wounds, accompanied by symptoms of general poisoning, were caused by the accidental entry of bacteria. The same opinion had been held before, and the novelty of Davaine's views lay chiefly in the excessive minuteness of the quantity necessary to produce the effect.

The chief benefit derived from these experiments and discussions in Paris was found in the great interest which was excited everywhere in the question. The experiments were repeated, and the conclusions examined in almost every pathological laboratory in Europe, and we have every reason to expect that, through this general examination and discussion, the truth will appear. From time to time articles appeared denying the virulence claimed for bacteria; the earliest of these was a paper submitted to the *Académie des Sciences*, in April, 1873, by M. Onimus, who had been experimenting under the direction of Prof. Robin. He placed putrefying blood in a bag made of a dialytic membrane, and immersed the whole in distilled water, which, after a few hours, was found to be filled with bacteria. Inoculation with the blood produced the usual results, but inoculation with the water caused no septic symptoms whatever; on the other hand, the same blood, when subjected to various processes which removed or destroyed the bacteria, retained its virulence, and from these experiments he drew the conclusion that the virus of putrid infection is not an organized ferment, not bacteria, but an albuminoid substance. Panum, who held similar views twenty years ago, has reasserted his belief in them in an article published in *Virchow's Archives*, for July, 1874, and during the last year the weight of testimony has all been in this direction. Clinical observation has been employed to confirm or refute the conclusions of experimental pathology, and has clearly demonstrated that the poisonous processes, of which we have spoken, can begin in the human body and proceed without the presence of bacteria, and that bacteria may be present in large quantities without the slightest symptom of any poisonous complication.

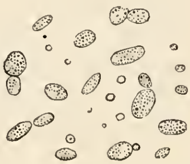


FIG. 4.—TORULÆ.—From a Solution of Ammonia Tartrate and Sodic Phosphate.

It is probable that their *rôle*, so far as disease is concerned, is as follows: While they have no power in themselves to excite disease (*diphtheria*, *vaccinia*, *septicæmia*, *typhoid fever*, etc.), they are able to absorb the poison (ferment?) which is capable of producing it, to "fix" it, as it is termed, and to give it up to any tissue with which they may come into contact, acting thus as carriers of contagion; then, after the abnormal process has been commenced in the body, a change is brought about in the tissues which renders them suitable for the rapid growth and multiplication of the bacteria, which, in turn, augment the change in the tissues, and thus there is formed a vicious circle, the consequences of which are too often fatal.

Any agent which destroys the life of the bacteria, or prevents their multiplication, breaks this circle and renders a cure possible.

The influence of bacteria in fermentation is still undecided, but, for the sake of completeness, the different opinions should be mentioned. It is admitted by all chemists that these or similar organisms are invariably present in some fermentations—*Bacterium termo*, or rod bacterium, in putrefaction, and the yeast-plant in alcoholic fermentation, for example; and while some claim that the process is due to the vitality and growth of these plants, others hold that this growth is an effect, not a cause; and a third party claim that the plants secrete the actual ferment.

According to Liebig, fermentation is an action which is produced in a fermentable substance by an albuminous matter which is dead and in spontaneous decomposition; that is, fermentation is a correlative phenomenon of death. On the other hand, Pasteur maintains that fermentation occurs only when a microscopical vegetable organism nourishes itself and multiplies at the expense of a part of the fermentable substance. All fermentation is accompanied by life; both processes (fermentation and growth) begin and end simultaneously; that is, fermentation is a correlative phenomenon of life.

The question of spontaneous generation is closely bound up with the question of fermentation, the supporters of the former claiming that life has its origin in a new combination of elements—*archebiosis*, a combination which resembles that which occurs in crystallization, and that the same causes which induce the chemical decompositions and subsequent combinations known as fermentation also bring about the combinations which result in life. The discussion has been very active, and, in France, Pasteur, skillful dialectician as he is, had to fight long and hard for the victory which he won. History shows that spontaneous generation has often been invoked to explain an unknown mode of production of life, and has always disappeared before advancing knowledge, and, now that it has been overthrown when claimed for the lowest forms of microscopical life, it probably will not reappear until an advance in the means of observation shall have revealed to observers still lower and more minute forms.

ANIMALS NOT AUTOMATA.

By ROWLAND G. HAZARD, Esq.

THE doctrine of necessity has been ably advocated by many acute philosophers, and is to-day, in various forms, including fatalism, the accepted creed of a large portion of mankind. A doctrine thus supported, and so immediately bearing upon our actions and our powers, cannot but be worthy of serious attention.

Prof. Huxley, approaching it on the material side, in the true spirit of philosophical inquiry, trustingly following wherever truth seemed to him to lead, and regardless of the apprehended consequences of attacking dominant creeds and opinions, has pushed this doctrine to its legitimate logical consequences, in the conclusion that all animals, man included, are but "conscious automata," moved and directed in their movements by extrinsic forces.

With him, I believe that all progress in knowledge is beneficial; I deprecate no enterprise in experiment, nor any boldness in speculation, if we are duly cautious in accepting and applying its results. The revelations of intelligent and honest inquiry always merit respectful and careful consideration, but are not properly exempt from scrutiny.

Although I have perhaps deviated as far on one side of the current opinions as Prof. Huxley has on the other, I cannot claim any credit for fearlessness of the consequences—my only apprehension in that respect being, that any arguments I may present, unrelieved by interesting experiments, will not excite sufficient interest to provoke either commendation or censure.

I think, however, I may properly say that, viewing the problem on the spiritual side, and carefully excluding popular prepossessions and theological dogmas, I have carried the opposite doctrine of "freedom" to its legitimate logical consequences in the conclusion that every being that wills is a creative first cause, having, in virtue of its attributes of knowledge, feeling, and volition, a power of itself to begin action. That the object of every volition or effort is to make the future different from what it otherwise would be, and hence, that every such being is an independent, self-active power in the universe, freely doing its part and coöperating with all other active intelligences in creating the future, which is always the composite result of the action of all such intelligences: that even an oyster, though it have no other power than that of moving its shell, may, so far, create the future and make it different from what it otherwise would be; and further, that as every intelligent being will conform its action to the conditions under, or upon, which it is to act, the action of each, in changing the conditions, may affect the action of any or of all others, and the action of the lowest may, in this way, influence that of the highest.

We both, however, admit knowledge and feeling, and recognize consciousness, or the phenomena of knowing, in man and other animals. In discussing questions so fundamental, this must be largely relied upon for the foundation and support of the argument on either side, and I will briefly state my views in regard to its authority.

Mind, as manifested in man and in brutes, I regard as entirely made up of a *capacity* for knowledge, a *susceptibility* to feeling, and a *faculty* of effort (will); this last being the only *power* we possess; and if it—the effort of intelligent being—is not the only power *known* to us, it is at least that power, of the existence of which we have the most direct and reliable evidence. The recipient and receptacle of all our knowledge, whatever its source, is consciousness. Our conscious perceptions and feelings (including emotions) are the foundation of all knowledge, and all belief; but the consciousness of one man, of itself, avails nothing against another having a different consciousness and a different belief. Belief is not a matter of will or of choice, but each must believe in conformity to his own consciousness, and retain his existing belief till his consciousness is in some way changed. The denial of this involves a contradiction, and we may assume, as a corollary to it, that it is not only reasonable, but a necessity, that we believe things to be as they appear to be, till we recognize a sufficient reason for believing that the appearances are deceptive. The testimony of consciousness is not equally reliable as to all subjects. In some cases it is conclusive, in others far from it. In regard to our internal perceptions, sensations, and emotions, our consciousness is conclusive evidence that we have them, and that they are what consciousness represents them to be. The consciousness of the sensation of pain is the pain itself; and the consciousness of perceiving that the whole is greater than its part is, itself, the perception of that fact, and there can be no question as to my actually having the sensation of pain, or as to my having the perception of the inequality. But the consciousness is not conclusive as to the conformity of the perception with the existing fact, nor as to any inference which I may draw from the sensation. One may have as full and decided perception of what is not, as of what is; and the liability to erroneous inferences from our sensations is a matter of daily experience.

Even a universal belief, founded on entire uniformity in the perceptions, or in the inferences from our sensations, is not conclusive. If it were, no error in such belief could ever be corrected. If, for instance, the belief that the sun daily revolved around the earth was once universal—and universal belief is regarded as conclusive—the present belief never could have been substituted. Still, to assume things to be as they appear to be, till a sufficient reason is given to the contrary, is a necessary condition to our progress in science and philosophy. If this proposition is denied, then all Prof. Huxley's array of facts and arguments may be fairly met by saying, "True, these things appear to be as you say, but, then, this appearing is no reason for supposing that they really are so." There would be an end to at least all physical investigations.

Instinct is, perhaps, a more important element in this discussion than Prof. Huxley has suggested—the various and vague notions in regard to it which obtain both in the popular and philosophical mind do much to confuse the consideration of voluntary and mechanical action.

Prof. Huxley assumes that instinctive action is mechanical. He says: "When we talk of the lower animals being provided with instinct, and not with reason, what we really mean is that, although they are sensitive, and although they are conscious, yet they act mechanically, and that their different states of consciousness, their sensations, their thoughts (if they have any), their volitions (if they have any), are the products and consequences of their mechanical arrangements. I must confess that this popular view is, to my mind, the only one which can be scientifically adopted."

There is much and high authority for the doctrine that instinctive actions are mechanical, but I believe it is very generally rejected by those who have observed the actions of animals without any knowledge of subtile theories to account for them. "What," incredulously exclaimed one of my grandchildren, on hearing of "Prof. Huxley's statement," "what sort of a mechanism is it that carries the wild-geese from Canada to the Gulf of Mexico every fall, and brings them back every spring?" This seems to me a fair illustration of the prevailing notions, indicating that Prof. Huxley is mistaken in assuming that the "popular view" favors the mechanical theory. I am aware that the "popular view" cannot be urged against special inquirers, whose object often is to correct prevailing errors, as well as to extend the limits of our knowledge; but misapprehension of the popular view may give a wrong direction to their efforts and make them unavailing.

No mechanical contrivance, no mechanism furnishes any *power*, but is only a means of applying power; and, even if the term mechanical embraces all the phenomena of matter in motion, we still have the question as to whether the mechanism or the matter moves by its own power, or is moved by the effort of some intelligent being.

He who views the perfect crystal as the direct creation of an intelligent designing power, and he who sees in it only the orderly effect of natural forces, will alike class it with the mechanical; so, too, both would speak of the celestial mechanism.

In investigating the *laws of Nature*, the one is observing and generalizing the uniform mode of God's voluntary action, the other is finding the necessary consequences of the action of material forces. Each attributes any phenomena which he cannot class with any of his generalizations to some inscrutable exercise of power—the one to intelligent effort, the other to unintelligent material movements; so that, in the mechanical, we have still the question as to the two forms of power—intelligence in effort, and matter in motion; and, as between these, admitting the existence of both, it seems most reasonable to attribute instinctive action, the action of a conscious, and hence intelligent being to the former, rather than to the latter. Instinctive action is not mechanical, even in the most extended sense of the term, but must be referred to the power of the being itself, and not to extrinsic power of any kind. Every voluntary effort is put forth to gratify a want, to make the future in some respect different from what, but for the effort, it would be. To do this, always requires that the effort, or series of efforts, should be adapted to the specific object, and that, in any series of them, each one should be in the appropriate consecutive order. There must be a mode, or plan of action. This plan is either a part of our knowledge, or is formed by means of it.

In all our actions, whether instinctive, rational, or habitual, we thus apply our knowledge to direct our efforts to the end desired, and there is not in the actions themselves, nor in their immediate antecedents, any difference whatever. In all of them it is but an effort suggested by the want, and directed to a given end by means of our knowledge. The difference is not in the action, nor in the knowledge, nor in the application of the knowledge, but one step farther back—in the manner in which we became possessed of the knowledge we apply. In a rational action we, by a preliminary effort, obtain this knowledge—we make the requisite plan. In the instinctive action this knowledge is innate; the plan is ready formed in the mind, requiring no premeditation, no deliberation to determine the mode of action. In the rational actions we acquire the knowledge of these plans for ourselves, and it is the preliminary effort to determine what to do, and how to do it—to find the mode of action—that tasks our intellectual abilities. But, when we have once formed the plan, and acted upon it often enough to remember its successive steps, so that we can repeat them in action by rote without any reference to the *rationale*, it becomes a plan ready formed in the mind, and the acting upon it becomes habitual. The instinctive and habitual actions, then, are precisely alike in this, that both are in conformity to a plan ready formed in the mind, requiring no effort to form them for the occasion, and differ only in this, that in the instinctive we found the plan ready formed, while in the habitual we *originally* formed it by our own effort. If, after the latter plans had become fixed in our memory, we should forget that we had originally acquired them by our own effort, we would know no difference between the instinctive and habitual action.

The popular consciousness of this similarity is expressed in the common adage that habit is second nature. If this view, which seems to me to account for all the peculiarities of instinctive action, is correct, instinct is not a distinct faculty, capacity, property, or quality, of being, which may be compared with or substituted for reason, but has relation only to the mode in which the knowledge by which we determine some of our actions was originally obtained. Whether the innate knowledge of modes and plans is by transmission, or otherwise, does not affect the theory. It is sufficient that they are thus ready formed in the being without effort of its own.

All intelligent actions, except perhaps those which are merely imitative, must in the first instance be either instinctive or rational, the habitual coming later through the transformation of the others by repetition and memory; the instinctive, however, not being materially changed thereby.

But the foundation of all our actions must be instinctive, there being no possible way in which we could ever learn that effort is the means of using either our muscular or mental powers.

In regard to the rational actions, I see no distinction in kind, but only in degree, between those of man and the lower animals. Descending in the scale of intelligence, we may, and probably will, reach a grade of beings which do not invent or form plans to meet new occasions for action, and the efforts of such must be wholly instinctive; but I have seen both dogs and horses draw inferences, and work out ingenious plans of action, adapted to conditions so unusual and so improbable to them, as to preclude the assumption that they had been specially provided by Nature, through hereditary transmission, or otherwise, with the knowledge of the plan suited to the occasion.

Prof. Huxley asserts that matter is a cause, a power not only in what is generally regarded as its own sphere, but that it also produces all mental phenomena. At the same time, while admitting the consciousness—the intelligence—of man and brutes, he denies to them the faculty of will, thus virtually denying to them any power.

He thus raises the question as to the power of matter, and also as to that of intelligent beings; at least of beings of no higher grade than man. It is not very clear whether or not he denies *all* intelligent power. In saying he has with him "Père Malebranche, who saw all things in God," he seems to recognize a supreme power; but then this power in his system might logically be but a deification of material forces, ignoring intelligent activity.

Against attributing power to matter, we may urge that its existence as a distinct entity has never been proved, and is seriously questioned. To assume that so important a quality inheres, and especially to assume that it inheres only in something, the existence of which is doubtful, when it may, with equal reason, be attributed to something, the existence of which is admitted, would be a grave philosophical and logical mistake.

Prof. Huxley admits the existence of intelligent (conscious) beings, but perhaps does not admit that power may, with equal reason, be attributed to them, nor perhaps that there is any reasonable doubt as to the existence of matter as a distinct entity; leaving these two questions open to discussion. In regard to the latter, he will probably admit that there is no decisive proof, and that the existence of matter is only an inference from the sensations which we attribute to its agency. But all the phenomena of these sensations are as well accounted for on the hypothesis that they are directly produced in our minds by some intelligent power as that they are the effects of matter.

If the material universe is regarded as the work of an intelligent Creator, working with design to produce a certain effect, then, upon either hypothesis, it is the expression of a conception of this Creator, existing as thought and imagery in his mind before he gave it palpable, tangible existence in ours, and the only question between the two modes is, whether, in making it palpable to us, he transfers this thought and imagery directly to our minds, or first paints, moulds, or carves them in a distinct material substance. The external universe would not, in the first of these modes, be any the less real. The sensations, which are all that under either hypothesis concern us, or that we know any thing about, would be the same in both cases. But we can no more impute power to such imagery than to an image in a mirror, and under this hypothesis material sensation would have no existence.

One consideration favoring the ideal theory is, that, under it, creation becomes more conceivable to us. We can, any of us, conceive or imagine a landscape, and vary its features at will. This is an incipient creation which, if we could impress it upon the mind of another, would be to him an external creation—to his vision as thoroughly material as the fields, and streams, and trees, he now looks out upon; and, if from any cause it should become fixed in the mind of him that conceived it, so that he could not change it at will, it would become to him an external reality. And this sometimes happens in abnormal conditions of the mind. In order to thus create what, at least to the visual sense, would be an external material creation, the only addition, then, which is required to the powers which we habitually exercise is that of impressing our conceptions upon others. With this addition we could create and give palpable existence to a universe, varying more or less from that now palpable to us. And this power of impressing our conceptions on others we are none of us wholly devoid of. Sculptors, painters, architects, and more especially poets, have it in marked degree.

We, however, find no rudiment of force in these incipient creations of our own, and, hence, they furnish us with no logical ground for attributing it to similar and more perfect creations of a Superior Intelligence. That these creations of our own are mostly evanescent, and those to which, with great labor, we give a persistent reality are very limited and imperfect, does not disprove the position that creation is more conceivable to us upon the ideal hypothesis than upon the material. The ideal hypothesis is also commended by the consideration that man, having, in a finite degree, all the other powers usually attributed to the Supreme Intelligence, lacks, under the material theory, the power of creating matter. Corresponding to His omnipotence, omniscience, and omnipresence, man has finite power and finite knowledge, and can make all the objects of his knowledge present, which is equivalent to a finite presence, limited, like our other attributes, to the sphere of our knowledge. This hypothesis, then, rounds out our ideas of creative intelligence, relieving us of the anomaly of the creation of matter as a distinct entity, for which, having in ourselves no conscious rudiment of a power to accomplish, we cannot conceive the possibility.

I may further observe that, if I am right in supposing that the only difference between our own incipient creations, of a landscape for instance, and the external scenery which we perceive, is that we can change the former at will, while the latter is fixed, it shows how narrow is the space that divides the creative powers of man from those of the Supreme Intelligence, and that the difference is mainly, if not entirely, in degree, and not in kind. This gives warrant to the logic, and shows how short the steps by which we attribute all creations and all changes, which we regard as beyond our own power and beyond that of other embodied intelligences known to us, to a superior intelligence, with the same powers which we possess and use to create and change, increased, I will not say infinitely, but to a degree corresponding to the effects which we see and ascribe to them.

If the existence of matter be admitted, it may still be urged that, being unintelligent, it can have no causative power, and can produce no change, for all changes in matter must be, by its motion, massive or atomic, and matter cannot move itself.

Even if it could be imbued with motive power, it could have no inducement, no tendency, to move in one direction rather than another; and a tendency which is equal in all directions is no tendency in any direction. If all matter were at this moment quiescent, even the materialists will not assert that it could of itself begin to move.

It may, however, be urged that both the arguments thus drawn from the difficulty of conceiving the creation of matter, and the necessity of motion to its causal power, may be met by the hypothesis that matter was not created, but has existed through a past eternity, and that its original condition was that of motion, and that there is no more difficulty in conceiving this than in conceiving that intelligence, with its activities, has had no beginning.

But, granting that matter has always existed, and originally had motion, and consequent power, still, if the tendency is to expend and exhaust this power in producing effects, by collision or otherwise, or, admitting the conservation of force, if its tendency is to become merely potential, then the force which it originally had, in virtue of being in motion, must, in the infinite period of its existence, have been either wholly exhausted or reduced to an infinitesimal, requiring the intervention of some active power to again give it any practical force.

But whether matter, supposing it to exist, can of itself, by means of its motion, be an independent power or force, still depends on another question, viz., Is the tendency of a body in motion, when the power which put it in motion is withdrawn, to continue to move, or to stop? In other words, is the application of extrinsic power required to keep it in motion, or is such application required to stop it? Having no power to move itself when once at rest, it could have no power to act, but could only be acted upon, and, if it has inertia, it would be a means of exhausting other force.

If when once in motion its tendency is to continue in motion, then it could be used as an instrument by which intelligent power, putting it in motion, could extend the effects of its own action in time and space.

If the tendency is to stop, then it could have no power or force, in virtue of being in motion, and could not even be a means of extending the effects of the action of other powers.

I have heretofore confessed my inability to solve this question as to the tendency of a moving body to continue its motion, or to stop when the motive power is withdrawn. I have not, perhaps, been able even to disentangle it from the empirical meshes in which it has become involved, and which, in my view, do not and cannot furnish any clew to its solution; but, until this point is settled, I do not see how matter, though in motion, can properly be regarded as a force, or even as a conserver of force imparted to it by some other power.

If matter in motion is power, then all its effects must be such as take place of necessity, it having no power to select or vary them, and, whatever the course of such effects, it cannot change. If, for instance, the moving body is approaching another body, then, as two bodies cannot occupy the same space, some effect must of necessity result from the collision; and all the effects of unintelligent cause or force must be from some like necessity. In this case the material hypothesis has an advantage, there being no apparent connection of *necessity* between an intelligent effort and its sequences. This, however, as matter cannot put itself in motion, nor, perhaps, even continue any motion imparted to it, may only make it an instrument of other power, and not a power itself.

Some of the considerations in favor of the existence of intelligent power have already incidentally arisen in connection with the question of the existence of material force, and others pertain to that of the will, to which we will now turn.

The question which Prof. Huxley raises is not merely, Does man will *freely?* but, Does he will *at all?* If he recognizes any volition in us, it is a volition in which we have no agency, but of which we are only conscious.

Between the two questions, of willing freely or not willing at all, there is perhaps little of practical importance; for, if our actions are controlled by some extrinsic power or force, it is not important whether this control is exerted directly on or in the action, or indirectly through controlled will. It might, perhaps, even be properly urged that, philosophically as well as popularly, a willing which is not free is a willing which is not willing, and this would identify the two questions.

Prof. Huxley, from divers physical experiments, comes to the conclusion that animals, including man, do not will, but that the effort-phenomena, of which we are conscious, are only a series, or the effect of a series, of mechanical changes of matter, over which we have no control. He admits that we have knowledge and feeling, and there is no difficulty in conceiving that these may exist without will, though the existence of either feeling or will without knowledge is impossible.

To most persons the actual making of an effort, or willing, seems to be as fully attested by their consciousness as a sensation is; and there is high philosophical authority for putting it in that category, in regard to which the consciousness is positively and of necessity conclusive. It seems to me, however, that there is room for a distinction between the consciousness of effort, and the effort itself. If the changes, which seem to us to be the consequences of our effort put forth with a preconception of these changes, and for the purpose of producing them, are really caused by some extrinsic power or force acting through us, it is quite conceivable that such a power, especially if intelligent, may impress us with the emotion of making an effort when we make none, though I see no reason why such a circuitous mode of action should be adopted. But, though the consciousness of making an effort is not conclusive as to the *actual* making, still, as it is of internal phenomena, it is evidence of a higher order than that which consciousness of a sensation gives as to the existence or character of the external phenomena.

The senses through which the external is presented may not act perfectly; and this, as compared with the consciousness of internal phenomena, makes an additional risk of error similar to that which arises from seeing an object through glass or in the reflection of a mirror, instead of directly without any intervening medium.

Those, then, who set up physical phenomena against our conscious ness of effort, labor under the disadvantage of impeaching the accuracy of the testimony by other testimony which is less reliable than that which they impeach.

Prof. Huxley admits that men and other animals know and feel. The existence, then, of that for which *power by effort* is claimed as an attribute, with these prerequisites to its exercise, is admitted.

On the other hand, any belief in matter or in its motion is but an inference from our sensations which, as we have seen, is not a necessary or conclusive inference; and hence we have no reliable evidence of the existence of matter, nor of the attributes which, if it exists, are essential to its having power.

In the first case, we know the existence of the active agent; its feeling, subjecting it to want; and its knowledge, enabling it to adopt a mode of gratifying its want, which are all the elements which are requisite to the exercise of a power by effort, and though we have no conclusive proof that it actually makes the effort, the testimony in regard to this, for reasons already stated, is more reliable than the inferences from our sensations, that matter exists, and that it moves, and that one portion impinges on another portion, all of which are essential to material causation. In the first case, the existence of the agent, with all the prerequisites to the exercise of power, is known. In the latter, not a single one of them is known. This shows that the material phenomena which Prof. Huxley presents are not, in this case, sufficient to rebut the testimony of consciousness that we do will—do make effort, and thereby produce change.

The further question, Do we ourselves determine our efforts? is identical with that of our freedom in willing, which I do not propose here to discuss, but will remark that it is not probable, perhaps it is not conceivable, that any unintelligent agent should create the whole system of wants, knowledge, and the application of knowledge involved in an effort, as just stated, and impress the *whole* as illusions on the mind of the actor; nor yet, that any blind force should direct the effort in exact conformity to the wishes and the preconceptions of the manner and the effect which are in the thoughts of him who has the emotion of making an effort, and which the unintelligent power, or agent, of course cannot know. Only an intelligent agent could know this; and, if the conforming of the effort to this want, knowledge, and preconception of the effect, must be referred to some intelligent being, it seems most reasonable to refer it to that which directly feels its own want, knows its own perceptions of the mode of gratifying the want, and its preconceptions of the effect to be produced, to all which the effort is to be conformed, and which, at the same time, is conscious of making the effort, and of thus conforming and directing it by its own knowledge. Between the sensation of making the effort, and the antecedent and subsequent knowledge of the subject of this sensation, there is a harmony which it seems hardly conceivable should be produced by any power not having this particular knowledge, and much less by a power incapable of knowing any thing.

As germane to the whole question of intelligent and material power, I will suggest that it would be unphilosophical to assume the existence of two primary powers, when one is sufficient to account for all the phenomena, and that as it seems hardly conceivable that matter should create intelligence with its phenomena—that what does not know should create a power to know—while, as already shown, it is quite conceivable that intelligence should create all that we know of matter and its phenomena, the hypothesis of power in matter should, on this ground, be discarded.

Let us now look at the very curious and interesting experiments upon which Prof. Huxley relies for his conclusion that animals, including man, are "conscious automata." He says that, if, when a man is so paralyzed that he is wholly unable to move his limbs, and has no sensation in them, "you tickle the soles of his feet with a feather, the limbs will be drawn up just as vigorously, perhaps a little more vigorously, than when he was in full possession of the consciousness of what happened to him." He also states that, in the case of a frog similarly paralyzed, the result of irritating the skin of the foot is the same: in both cases the foot being drawn *from* the source of irritation. This certainly bears a very close resemblance to the voluntary action of an intelligent being, conscious of the irritation, and seeking relief from it by its own efforts. Prof. Huxley, however, positively asserts that the animal could not feel or will, and this being so, he seems to be justified, by common usage, in calling the action "mechanical." But, as I have already suggested, this term is applied to material phenomena, whether they are results of matter in motion, or of the uniform modes of God's action.

Other experiments still more remarkable are presented. He says: "Take this creature (the same frog), which certainly cannot feel, and touch the skin of the side of its body with a little acetic acid, which, in a frog that could feel, would give rise to great pain. In this case there can be no pain. . . . Nevertheless, the frog lifts up the limb on the same side, and applies the foot to rubbing off the acetic acid; and what is still more remarkable, if you hold down the limb, so that the frog cannot use it, he will, by-and-by, take the limb of the other side and turn it across the body, and use it for the same rubbing process."

This goes a step further, requiring a more complicated mechanism to direct the force, when it fails to move one foot, to the movement of the other. In still another case, he says: "Suppose the foremost two-thirds of the brain taken away, the frog is then absolutely devoid of any spontaneity; it will remain forever where you leave it; it will not stir, unless it is touched; . . . but, . . . if you throw it in the water, it begins to swim—swims just as well as the perfect frog does; . . . and the only way we can account for this is, that the impression made on the sensory nerves of the skin of the frog by the contact of the water conveys to the central nervous apparatus a *stimulus* which sets *going a certain machinery* by which all the muscles of swimming are brought into play in due order of succession. Moreover, if the frog be stimulated, be touched by some irritating body, although we are quite certain it cannot feel, it jumps or walks as well as the complete frog can do."

Most persons, I presume, have seen men and other animals made so torpid by injury or disease, that they would show little sign of vitality, and great indisposition to make any effort, but that they still moved when pricked with a pin has been generally regarded as evidence that they still felt; and the movements they would make to avoid danger, or escape pain, have been thought to be conclusive that they were *not* "absolutely devoid of any spontaneity."

It is not uncommon for a man, who, in ordinary circumstances seemed wholly unable to move his limbs, under great or sudden excitement, as the approach of fire or sudden apprehension of drowning, to make vigorous and successful muscular efforts.

The common observer, then, would infer from the foregoing experiments that Prof. Huxley was not justified in inferring, from the fact of mutilation, that the frog was "absolutely devoid of any spontaneity," and that "we are quite certain it cannot feel." If the facts stated do not prove that the frog still feels, still wills, and still has knowledge to direct its efforts to get rid of the irritation, it seems difficult to devise any mode of proof that a being ever feels, knows, or wills. Prof. Huxley admits that we do feel and know, but infers from these experiments that we do not will. If his theory of them is correct, they seem to afford little ground for this distinction.

Prof. Huxley, in still another case, says of a frog deprived of the most anterior portion of the brain, that "it will sit forever in the same spot. It sees nothing, it hears nothing," yet placed on the hand would, on the turning of the hand, make all the movements necessary to prevent its falling off, and that "these movements are performed with the utmost steadiness and precision, and you may vary the position of your hand, and the frog, so long as you are reasonably slow in your movements, will work backward and forward *like a clock*." Referring to this experiment, Prof. Huxley afterward says: "If the frog were a philosopher he might reason thus: 'I feel myself uncomfortable and slipping, and, feeling myself uncomfortable, I put my legs out to save myself, knowing that I shall tumble if I do not put them farther. I put them farther still, and my volition brings about all these beautiful adjustments which result in my sitting safely!' But, if the frog so reasoned, he would be entirely mistaken, for the frog does the thing just as well when he has no reason, no sensation, no possibility of thought of any kind. The only conclusion, then, at which there seems any good ground for arriving is, that animals are machines, but that they are conscious machines." And he afterward says: "Undoubtedly, I do hold that the view I have taken of the relations between the physical and mental faculties of brutes applies in its fullness and entirety to man." Of this last experiment Prof. Huxley further says: "And what is still more wonderful is, that if you put the frog on a table, and put a book between him and the light, and give him a little jog behind, he will jump (take a long jump, very possibly), but he won't jump against the book, he will jump to the right or to the left, but he will get out of the way, showing that, although he is absolutely insensible to ordinary impressions of light, there is still something which passes through the sensory nerve, acts upon the machinery of his nervous system, and causes it to adapt itself to the proper action." This is certainly very wonderful, and becomes even more so when taken in connection with the next case—that of a man who had been shot in the head, and who, Prof. Huxley says, "is in a condition absolutely parallel to that of the frog," but afterward says, "very nearly" in the same condition, and also says, "he has only one sense organ in a state of activity, namely, that of touch, which is exceedingly delicate." Yet of this man, thus described as virtually in the same condition as the frog, except that he has a very delicate sense of touch, we are told that, "if an obstacle is put in his way, he knocks against it, feels it, and goes to one side; if you push him in any direction, he goes straight on until something stops him."

It is certainly very remarkable that the frog, with no sense at all, avoids leaping against the obstruction, while the man, with a delicate sense of touch, and other conditions parallel or very nearly the same as the frog, knocks against it. It must be a very curious mechanism which can make such discrimination in the effects of its action.

Let us examine the case of the frog a little further. Prof. Huxley ascribes its leaping obliquely and not directly forward to "a something which passes through the sensory nerve, *acts upon the machinery* of his nervous system, and causes it to adapt itself to the proper action," and this "although he is absolutely insensible to ordinary impressions of light." Does Prof. Huxley mean that this "something" passes through the book, and thus reaches the sensory nerve, and that, but for the intervening book, it would not pass that way? Under some circumstances, it might be that a conductor would facilitate the passage of a "something" which would not pass through the air, but in this case there is the difficulty of getting this "something" to the book, and then of sending it forward through the air. The only alternative seems to be to suppose that when there was no intervening book, a "something" passed to the frog which was necessary to cause it to jump directly forward, the passage of which the book prevented. Neither of these hypotheses seems satisfactory, even if no objection is made to the unknown "something."

To those skilled in scientific investigation it may not appear important, but I apprehend that many, like myself, not familiar with its modes, will regret that the experiment in this case was not pushed somewhat further. To find, for instance, what would be the effect when the obstruction extended equally to the right and to the left? What if it extended indefinitely both ways? And what, when it made an entire circle around the frog in the centre; and what if in different positions other than the centre.

But, even admitting, in all the cases, all that Prof. Huxley claims as ascertained facts, what does it all amount to further than that he has brought to light some additional phenomena which, like the movements of the material universe and the pulsations of the heart, must be referred to some inscrutable agency? He who believes only in intelligent power refers them, with all else that he does not effect by his own efforts, and which he regards as beyond the power of any known embodied intelligence, to a Superior Intelligence, acting through the instrumentality of matter or otherwise; while he who believes only in material causation attributes them to the influence of matter, in some form or some mode of its movement differing from those forms and modes which are familiar to him. Nor is it material how many steps there may be between the power applied and the effect. If there are three or thirty ivory balls in a right line, and the first of them is put in motion causing each one successively to impinge on the next, the final effect of motion in the last is caused by the power applied to the first. We may by our own efforts put the alleged power of matter in action, or may thus act through the uniform modes of God's action.

In voluntary muscular movement the intermediate effect of a flow of blood to the contracting muscle has long been known; now, the propagation of molecular movement is ascertained. That we are not conscious of the movement of the molecules indicates (though far from conclusively) that we do not ourselves move them, but this does not indicate that the muscular movement is not the result of our own effort working through other agencies. That he who throws the stone which kills a bird does not know what curve the stone will describe, nor by what power its motion is continued after it leaves his hand, does not show that he is not the cause of the killing.

If the knowledge of the intermediate changes is a necessary condition to the exercise of the power which produces the final result, what becomes of the hypothesis of causation by material movements, or forces, which know nothing? In regard to the special phenomena in hand, it would seem that no power less facile, or less variable and adjustable in its application than that of intelligent effort, could be adequate; and that no blind power or force, the effects of which must of necessity be uniform, could, from the same conditions, produce such diverse effects as those attributed to the man and the frog.

Considering the clear line of demarcation which there is between those cases of change for which we are conscious of making effort and those for which we are not, I do not see how the discovery of any number of cases of the latter discredits the testimony of consciousness as to the former. All this exhibition of material phenomena, then, really weighs very little on either side of the question as to the existence of intelligent or material causality; and this little, I think, may be fairly claimed on the side of the intelligent.

There is another criterion which, as Prof. Huxley, in applying a somewhat analogous test, has very appropriately said, "though it could not be used in dealing with questions which are susceptible of demonstration, is well worthy of consideration in a case like the present." I cannot demonstrate, but I have great faith in the proposition that all progress in truth will increase the happiness and conduce to the elevation of man. I also have some faith in the converse of this proposition —that whatever tends to diminish our happiness and degrade our position will be found to be not true.

In this case, by adopting Prof. Huxley's views, we should be deprived of all the dignity of conscious power, and with it of all the cheering and elevating influences of the performance of duty; for that which has no power can have no duties. Instead of companionship with a Superior Intelligence, communicating his thoughts to us in the grandeur and beauty of the material universe—the poetic imagery, of which it is the pure and perfect type—and in his yet higher and more immediate manifestations in the soul, we should be doomed to an inglorious fellowship with insensate matter, and subjected to its blind forces. That sublime power—that grandeur of effort by which the gifted logician, with resistless demonstration, permeates and illuminates realms which it tasks the imagination to traverse; and that yet more God-like power by which the poet commands light to be, and light breaks through chaos upon his beautiful creations, would no more awaken our admiration, or incite us to lofty effort. We should be degraded from the high and responsible position of independent powers in the universe—co-workers with God in creating the future—to a condition of mere machines and instruments operated by "stimuli" and "molecules;" and, though still with knowledge and sensibility to know and feel our degraded position—"so abject! yet alive"—with no power to apply our knowledge in effort to extricate, and to elevate ourselves. We might still have the knowledge of good and evil; but, having no power to foster the one, or to resist the other, this knowledge, with all its inestimable consequences—all the aspirations which it awakens, and all the incentives to noble deeds which it, in combination with effort, alone makes possible—would be lost. And with it, we might almost say, there would again be no death, for all mutation now being but changes in the indestructible atoms of matter, by means of its motion, also indestructible and eternal, there would be little left to die, as there would again be little left to live for. For all this, I see no compensation in the doctrines now so clearly and frankly presented.

CELESTIAL CHEMISTRY.[1]

By T. STERRY HUNT, LL. D., F. R. S.

AMONG the most significant advances in chemical theory are those relating to the action of heat on bodies. If we define chemistry, as I have been tempted to do, as that science which treats of the relations to one another of the different forms of mineral (i. e., unorganized) matter, and their transformations under the physical agencies of heat, light, and electricity, we shall see how difficult it is, in a sketch like this, to draw the line between physics and chemistry. This becomes still more evident when we see in light the chemical constitution of matter, as it were, revealed and made visible to us by the spectroscope, or study the electric current parting in a mysterious manner the components of bodies. Time would fail us to follow the trains of thought thus opened, but I cannot forbear to say somewhat of the relations of temperature to chemical species, and of the power of heat to unloose the bonds of chemical combination. The admirable researches of Grove, followed by those of Henri St.-Claire Deville and his fellow-laborers, have shown us that, at an elevated temperature, such bodies as water, hydrate of potassium, and hydrochloric acid, are more or less completely resolved into their constituent elements, the affinities of which are suspended. In the principle of dissociation by heat we have an explanation of many chemical reactions hitherto enigmatical. The decomposition of bodies by heat is, moreover, assimilated to the phenomenon of volatilization: the rate of decomposition at a given temperature varying with the pressure, and with the nature of the atmosphere which surrounds the unstable body. The phenom-

[1] Extract from Dr. Hunt's Address at the Northumberland Centennial, on "A Century's Progress in Theoretical Chemistry."

ena of dissociation are seen in a wonderful degree in the sun, the fixed stars, and the nebulæ. It is not necessary to recall to you the marvelous field of celestial chemistry which the spectroscope, in the hands of Kirchhoff and his followers, has made known to us, nor the proofs that the solar atmosphere contains in a dissociated state very many of the elements which in our own planet are met with in a free state only in the laboratory of the chemist. It is instructive to compare the spectra of the various fixed stars with each other, from white stars like Sirius, to yellow stars like Aldebaran and our own sun, and red stars like Alpha Orionis and Antares, and to note in these three classes an increasing complexity of chemical composition. In the first, with a predominance of hydrogen, we see only faint lines of magnesium, sodium, calcium, iron, and a few other metals, while in the second, though free hydrogen still abounds, the number of metallic elements is greatly augmented, and finally in the red stars hydrogen is seen only in combination, as aqueous vapor, the metals are wanting, and the metalloids and their compounds appear. If, in accordance with the nebular hypothesis, we look upon these different types of stars as representing successive stages in the process of condensation from nebula to planet, we may also see in them a gradual evolution of the more complex from the simple forms of matter by a process of celestial chemistry. Such was the view put forward by F. W. Clarke in January, 1873, and some months later by Lockyer, who has reiterated and enforced these suggestions, and, moreover, connected them with the speculations of Dumas on the composite nature of the elements. The white stars are the hottest, and in the atmosphere of these bodies the various metals, according to Lockyer, make their appearance in the order of their vapor-densities.

I ventured, in 1867, while speculating on the phenomena of dissociation, to remark that, although from the experiments of the laboratory we can only conjecture the complex nature of the so-called elementary substances, we may expect that their "further dissociation in stellar or nebulous masses may give us evidence of matter still more elemental." Now, while the nebulæ, when scanned by the spectroscope, show us only the lines of hydrogen and nitrogen, the two lightest forms of gaseous matter known to chemistry, it is remarkable that the recent studies of the solar chromosphere reveal to us the existence of an unknown gaseous element which, from its extension beyond even the layer of partially cooled hydrogen, must, according to the deductions of Mr. Johnson Stoney, be still lighter than this gas. The green line by which this substance is distinguished is not as yet identified with that of any terrestrial element. Is it not possible that we have here that more elemental form of matter which, though not seen in the nebulæ, is liberated by the intense heat of the solar sphere, and may possibly correspond to the primary matter conjectured by Dumas, having an equivalent weight one-fourth that of hydrogen? Mention should also be made of the unknown element conjectured by Huggins to exist in some nebulæ. This conception of a first matter or *Urstoff* has also been maintained by Hinrichs, who has put forward an argument in its favor from a consideration of the wave-lengths in the lines of the spectra of various elements.

It is curious in this connection to note that Lavoisier suggested that hydrogen, nitrogen, and oxygen, with heat and light, might be regarded as simpler forms of matter from which all others were derived. The nebulæ, which we conceive as condensing into suns and planets, show us only two of the three elements of our terrestrial envelope, which is made up of air and aqueous vapor. If now we admit, as I am disposed to do with Mattieu Williams, that our atmosphere and ocean are not simply terrestrial, but cosmical, and are a portion of the medium which, in an attenuated form, fills the interstellary spaces, these same nebulæ and their resulting worlds may be evolved by a process of chemical condensation from this universal atmosphere, to which they would sustain a relation somewhat analogous to that of clouds and rain to the aqueous vapor around us. This, though it may be regarded as a legitimate and plausible speculation, is at present nothing more, and we may never advance beyond conjecture as to the relation of the various forms of so-called elemental matter, and to the processes which govern the evolution of the celestial spheres. You will, I trust, pardon this excursion to the regions of space and the realm of imagination into which I have led you, and return with me to the consideration of a new chapter in chemical theory.

REPLY TO THE CRITICS OF THE BELFAST ADDRESS.[1]

By JOHN TYNDALL, LL. D., F. R. S.

I TAKE advantage of a pause in the issue of this Address, to add a few prefatory words to those already printed.

The world has been frequently informed of late that I have raised up against myself a host of enemies; and considering, with few exceptions, the deliverances of the press, and more particularly of the religious press, I am forced sadly to admit that the statement is only too true. I derive some comfort, nevertheless, from the reflection of Diogenes, transmitted to us from Plutarch, that "he who would be saved must have good friends or violent enemies; and that he is best off who possesses both." This "best" condition, I have reason to believe, is mine.

Reflecting on the fraction I have read of recent remonstrances, ap-

[1] Preface to the seventh edition of the Address before the British Association at Belfast, with an Appendix on "Scientific Materialism," etc. D. Appleton & Co.

peals, menaces, and judgments—covering not only the world that now is, but that which is to come—it has interested me to note how trivially men seem to be influenced by what they call their religion, and how potently by that "nature" which it is the alleged province of religion to eradicate or subdue. From fair and manly argument, from the tenderest and holiest sympathy on the part of those who desire my eternal good, I pass by many gradations, through deliberate unfairness, to a spirit of bitterness which desires, with a fervor inexpressible in words, my eternal ill. Now, were religion the potent factor, we might expect a homogeneous utterance from those professing a common creed; while, if human nature be the really potent factor, we may expect utterances as heterogeneous as the characters of men. As a matter of fact we have the latter; suggesting to my mind that the common religion professed and defended by these different people is merely the accidental conduit through which they pour their own tempers, lofty or low, courteous or vulgar, mild or ferocious, holy or unholy, as the case may be. Pure abuse, however, I have deliberately avoided reading, wishing to keep, not only hatred, malice, and uncharitableness, but even every trace of irritation, far away from my side of a discussion which demands not only good temper, but largeness, clearness, and many-sidedness of mind, if it is to guide us even to provisional solutions.

At an early stage of the controversy a distinguished professor of the University of Cambridge was understood to argue—and his argument was caught up with amusing eagerness by a portion of the religious press—that my ignorance of mathematics renders me incompetent to speculate on the proximate origin of life. Had I thought his argument relevant, my reply would have been simple; for before me lies a printed document, more than twenty-two years old, bearing the signature of this same learned professor, in which he was good enough to testify that I am "well versed in pure mathematics."

In connection with his limitation of speculative capacity to the mathematician, the gentleman just referred to offered what he considered a conclusive proof of the being of a God. This solemn problem he knocked off in a single paragraph. It interests me profoundly to reflect upon the difference between the state of mind which could rest satisfied with this performance and that of the accomplished poet, and more than accomplished critic, who in "Literature and Dogma" pronounces the subject of the professor's demonstration "an unverifiable hypothesis." Whence this difference? Were the objective facts decisive, both writers would come to the same conclusion: the divergence is, therefore, to be referred to the respective subjective organs which take the outward evidence in. When I turn, as I have done from time to time for years, to the articles and correspondence in our theological journals, and try to gather from them what our religious teachers think of this universe and of each other, they seem to me to be as far removed from nineteenth-century needs as the priests of the Homeric period. Omniscience might see in our brains the physical correlatives of our differences; and, were these organs incapable of change, the world, despite this internal commotion, would stand still as a whole. But happily that Power which, according to Mr. Arnold, "makes for righteousness" is intellectual as well as ethical; and by its operation, not as an outside but as an inside factor of the brain, even the mistaken efforts of that organ are finally overruled in the interests of truth.

It has been thought, and said, that, in the revised Address as here published, I have retracted opinions uttered at Belfast. A Roman Catholic writer, who may be taken as representative, is specially strong upon this point. Startled by the deep chorus of dissent with which my dazzling fallacies have been received, he convicts me of trying to retreat from my position. This he will by no means tolerate. "It is too late now to seek to hide from the eyes of mankind one foul blot, one ghastly deformity. Prof. Tyndall has himself told us how and where this Address of his was composed. It was written among the glaciers and the solitudes of the Swiss mountains. It was no hasty, hurried, crude production; its every sentence bore marks of thought and care."

My critic intends to be severe: he is simply just. In the "solitudes" to which he refers I worked with deliberation; endeavoring even to purify my intellect by disciplines similar to those enjoined by his own Church for the sanctification of the soul. I tried in my ponderings to realize not only the lawful, but the expedient; and to permit no fear to act upon my mind save that of uttering a single word on which I could not take my stand, either in this or any other world.

Still my time was so brief, and my process of thought and expression so slow, that, in a literary point of view, I halted, not only behind the ideal, but behind the possible. Hence, after the delivery of the Address, I went over it with the desire, not to revoke its principles, but to improve it verbally, and above all to remove any word which might give color to the notion of "heat and haste." In holding up as a warning to writers of the present the errors and follies of the denouncers of the past, I took occasion to compare the intellectual propagation of such denouncers to that of thistle-germs; the expression was thought offensive, and I omitted it. It is still omitted from the Address. There was also another passage, which ran thus: "It is vain to oppose this force with a view to its extirpation. What we should oppose, to the death if necessary, is every attempt to found upon this elemental bias of man's nature a system which should exercise despotic sway over his intellect. I do not fear any such consummation. Science has already, to some extent, leavened the world, and it will leaven it more and more. I should look upon the mild light of science breaking in upon the minds of the youth of Ireland, and strengthening gradually to the perfect day, as a surer check to any intellectual or spiritual tyranny which might threaten this island than the laws of princes or the swords of emperors. Where is the cause of fear? We fought and won our battle even in the middle ages; why should we doubt the issue of a conflict now?"

This passage also was deemed unnecessarily warm, and I therefore omitted it. It was an act of weakness on my part to do so. For, considering the aims and acts of that renowned and remorseless organization which for the time being wields the entire power of my critic's Church, not only resistance to its further progress, but, were it not for the intelligence of Roman Catholic laymen, positive restriction of its present power for evil, might well become the necessary attitude of society as regards that organization. With some slight verbal alterations, therefore, which do not impair its strength, the passage has been restored.

My critic is very hard upon the avowal in my preface regarding atheism. But I frankly confess that his honest hardness and hostility are to me preferable to the milder but less honest treatment which the passage has received from members of other churches. He quotes the paragraph, and goes on to say: "We repeat this is a most remarkable passage. Much as we dislike seasoning polemics with strong words, we assert that this apology only tends to affix with links of steel to the name of Prof. Tyndall the dread imputation against which he struggles."

Here we have a very fair example of subjective religious vigor. But my quarrel with such exhibitions is that they do not always represent objective fact. No atheistic reasoning can, I hold, dislodge religion from the heart of man. Logic cannot deprive us of life, and religion is life to the religious. As an experience of consciousness, it is perfectly beyond the assaults of logic. But the religious life is often projected in external forms—I use the word in its widest sense—by no means beyond the reach of logic, which will have to bear—and to do so more and more as the world becomes more enlightened—comparison with facts. The subjective energy to which I have just referred is also a fact of consciousness not to be reasoned away. My critic feels, and takes delight in feeling, that I am struggling, and he obviously experiences the most exquisite pleasures of "the muscular sense" in holding me down. His feelings are as real as if his imagination of what mine are were equally real. His picture of my "struggles" is, however, a mere phantasm. I do not struggle. I do not fear the charge of atheism; nor should I even disavow it, in reference to any definition of the Supreme which he, or his order, would be likely to frame. His "links" and his "steel" and his "dread imputations" are, therefore, even more unsubstantial than my "streaks of morning cloud," and they may be permitted to vanish together.

What are the conceptions in regard to which I place myself in the position here indicated? The pope himself provides me with an answer. In the Encyclical Letter of December, 1864, his Holiness writes: "In order that God may accede more easily to our and your prayers, let us employ in all confidence, as our Mediatrix with Him, the Virgin Mary, Mother of God, who sits as a Queen on the right hand of her only-begotten Son, in a golden vestment, clothed around with various adornments."

In regard to this, as to other less pictorially anthropomorphic and sartorial conceptions of the Supreme, I stand in an attitude of unbelief; for, taken in connection with what is known of the extent, organization, and general behavior of this universe, they lack the congruity necessary to commend them to me as truth.

Soon after the delivery of the Belfast Address, the Protestant Bishop of Manchester did me the honor of noticing it; and, in reference to that notice, a brief and, I trust, not uncourteous remark was introduced into my first preface. Since that time the bishop's references to me have been very frequent. Assuredly this is to me an unexpected honor. Still a doubt may fairly be entertained whether this incessant speaking before public assemblies on emotional subjects does not tend to disturb that equilibrium of head and heart which it is always so desirable to preserve—whether, by giving an injurious predominance to the feelings, it does not tend to swathe the intellect in a warm haze, thus making the perception, and consequent rendering of facts, indefinite, if not untrue. It was to the bishop I referred in a recent brief discourse[1] as "an able and, in many respects, a courageous man, running to and fro upon the earth, and wringing his hands over the threatened loss of his ideals." It is doubtless to this sorrowing mood—this partial and, I trust, temporary overthrow of the judgment by the emotions—that I must ascribe a probably unconscious, but still grave, misrepresentation contained in the bishop's last reference to me. In the *Times* of November 9th, he is reported to have expressed himself thus: "In his lecture in Manchester, Prof. Tyndall as much as said that at Belfast he was not in his best mood, and that his despondency passed away in brighter moments." Now, considering that a *verbatim* report of the lecture was at hand in the *Manchester Examiner*, and that my own corrected edition of it was to be had for a penny, the bishop, I submit, might have afforded to repeat what I actually said, instead of what I "as much as said." I am sorry to add that his rendering of my words is a vain imagination of his own. In my lecture at Manchester there was no reference, expressed or implied, to my moods in Belfast.

To all earnest and honest minds acquainted with the paragraph of

[1] *See* THE POPULAR SCIENCE MONTHLY for January, 1875.

my first preface, on which the foregoing remark of Bishop Fraser, and similar remarks of his ecclesiastical colleagues, not to mention those of less responsible writers, are founded, I leave the decision of the question whether their mode of presenting this paragraph to the public be straightforward or the reverse.

These minor and more purely personal matters at an end, the weightier allegation remains—that at Belfast I misused my position by quitting the domain of science, and making an unjustifiable raid into the domain of theology. This I fail to see. Laying aside abuse, I hope my accusers will consent to reason with me. Is it not competent for a scientific man to speculate on the antecedents of the solar system? Did Kant, Laplace, and William Herschel, quit their legitimate spheres when they prolonged the intellectual vision beyond the boundary of experience, and propounded the nebular theory? Accepting that theory as probable, is it not permitted to a scientific man to follow up in idea the series of changes associated with the condensation of the nebulæ; to picture the successive detachment of planets and moons, and the relation of all of them to the sun? If I look upon our earth, with its orbital revolution and axial rotation, as one small issue of the process which made the solar system what it is, will any theologian deny my right to entertain and express this theoretic view? Time was when a multitude of theologians would be found to do so —when that arch-enemy of science which now vaunts its tolerance would have made a speedy end of the man who might venture to publish any opinion of the kind. But that time, unless the world is caught strangely slumbering, is forever past.

As regards inorganic Nature, then, I may traverse, without let or hinderance, the whole distance which separates the nebulæ from the worlds of to-day. But only a few years ago this now conceded ground of science was theological ground. I could by no means regard this as the final and sufficient concession of theology; and at Belfast I thought it not only my right but my duty to state that, as regards the organic world, we must enjoy the freedom which we have already won in regard to the inorganic. I could not discern the shred of a title-deed which gave any man, or any class of men, the right to open the door of one of these worlds to the scientific searcher, and to close the other against him. And I considered it frankest, wisest, and in the long-run most conducive to permanent peace, to indicate without evasion or reserve the ground that belongs to Science, and to which she will assuredly make good her claim.

Considering the freedom allowed to all manner of opinions in England, surely this was no extravagant position for me to assume. I have been reminded that an eminent predecessor of mine in the presidential chair expressed a totally different view of the Cause of things from that enunciated by me. In doing so he transgressed the bounds of science at least as much as I did; but nobody raised an outcry against him. The freedom that he took I claim, but in a more purely scientific direction. And looking at what I must regard as the extravagances of the religious world; at the very inadequate and foolish notions concerning this universe entertained by the majority of our religious teachers; at the waste of energy on the part of good men over things unworthy, if I might say it without discourtesy, of the attention of enlightened heathens: the fight about the fripperies of Ritualism, the mysteries of the Eucharist, and the Athanasian Creed; the forcing on the public view of Pontigny Pilgrimages; the dating of historic epochs from the definition of the Immaculate Conception; the proclamation of the Divine Glories of the Sacred Heart—standing in the midst of these insanities, it did not appear to me extravagant to claim the public tolerance for an hour and a half for the statement of what I hold to be more reasonable views: views more in accordance with the verities which science has brought to light, and which many weary souls would, I thought, welcome with gratification and relief.

But to come to closer quarters. The expression to which the most violent exception has been taken is this: "Abandoning all disguise, the confession I feel bound to make before you is that I prolong the vision backward across the boundary of the experimental evidence, and discern, in that Matter which we, in our ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life." To call it a "chorus of dissent," as my Catholic critic does, is a mild way of describing the storm of opprobrium with which this statement has been assailed. But, the first blast of passion being past, I hope I may again ask my opponents to consent to reason. First of all, I am blamed for crossing the boundary of the experimental evidence. I reply that this is the habitual action of the scientific mind—at least of that portion of it which applies itself to physical investigation. Our theories of light, heat, magnetism, and electricty, all imply the crossing of this boundary. My paper on the "Scientific Use of the Imagination" illustrates this point in the amplest manner; and in the lecture above referred to I have sought, incidentally, to make clear how in physics the experiential incessantly leads to the ultra-experiential; how out of experience there always grows something finer than mere experience, and that in their different powers of ideal extension consists for the most part the difference between the great and the mediocre investigator. The kingdom of science, then, cometh not by observation and experiment alone, but is completed by fixing the roots of observation and experiment in a region inaccessible to both, and in dealing with which we are forced to fall back upon the picturing power of the mind.

Passing the boundary of experience, therefore, does not, in the abstract, constitute a sufficient ground for censure. There must have been something in my particular mode of crossing it which provoked this tremendous "chorus of dissent."

Let us calmly reason the point out. I hold the nebular theory as it was held by Kant, Laplace, and William Herschel, and as it is held by the best scientific intellects of to-day. According to it, our sun and planets were once diffused through space as an impalpable haze, out of which, by condensation, came the solar system. What caused the haze to condense? Loss of heat. What rounded the sun and planets? That which rounds a tear—molecular force. For æons, the immensity of which overwhelms man's conceptions, the earth was unfit to maintain what we call life. It is now covered with visible living things. They are not formed of matter different from that of the earth around them. They are, on the contrary, bone of its bone and flesh of its flesh. How were they introduced? Was life implicated in the nebulæ—as part, it may be, of a vaster and wholly Incomprehensible Life; or is it the work of a Being standing outside the nebulæ, who fashioned it as a potter does his clay, but whose own origin and ways are equally past finding out? As far as the eye of science has hitherto ranged through Nature, no intrusion of purely creative power into any series of phenomena has ever been observed. The assumption of such a power to account for special phenomena has always proved a failure. It is opposed to the very spirit of science, and I therefore assumed the responsibility of holding up in contrast with it that method of Nature which it has been the vocation and triumph of science to disclose, and in the application of which we can alone hope for further light. Holding, then, that the nebulæ and all subsequent life stand to each other in the relation of the germ to the finished organism, I reaffirm here, not arrogantly, or defiantly, but without a shade of indistinctness, the position laid down in Belfast.

Not with the vagueness belonging to the emotions, but with the definiteness belonging to the understanding, the scientific man has to put to himself these questions regarding the introduction of life upon the earth. He will be the last to dogmatize upon the subject, for he knows best that certainty is here for the present unattainable. His refusal of the creative hypothesis *is less an assertion of knowledge than a protest against the assumption of knowledge* which must long, if not forever, lie beyond us, and the claim to which is the source of manifold confusion upon earth. With a mind open to conviction, he asks his opponents to show him an authority for the belief they so strenuously and so fiercely uphold. They can do no more than point to the Book of Genesis, or some other portion of the Bible. Profoundly interesting and indeed pathetic to me are those attempts of the opening mind of man to appease its hunger for a Cause. But the Book of Genesis has no voice in scientific questions. To the grasp of geology, which it resisted for a time, it at length yielded like potter's clay; its authority as a system of cosmogony being discredited on all hands by the abandonment of the obvious meaning of its writer. It is a poem, not a scientific treatise. In the former aspect it is forever beautiful; in the latter aspect it has been, and it will continue to be, purely obstructive and hurtful. To *knowledge* its value has been negative, leading, in rougher ages than ours, to physical, and even in our own "free" age, as exemplified in my own case, to moral violence.

To the student of cause and effect no incident connected with the proceedings at Belfast is more instructive than the deportment of the Catholic hierarchy of Ireland; a body usually wise enough not to confer notoriety upon an adversary by imprudently denouncing him. The *Times*, to which I owe nothing on the score of sympathy, but a great deal on the score of fair play, where so much has been unfair, thinks that the Irish cardinal, archbishops, and bishops, in their recent manifesto, promptly and adroitly employed a weapon which I, at an unlucky moment, had placed in their hands. The antecedents of their action cause me to regard it in a different light; and a brief reference to these antecedents will, I think, illuminate not only their proceedings regarding Belfast, but other doings which have been recently noised abroad.

Before me lies a document, bearing the date of November, 1873, but which, after appearing for a moment, unaccountably vanished from public view. It is a memorial addressed by seventy of the students and ex-students of the Catholic University in Ireland to the Episcopal Board of the University. This is the plainest and bravest remonstrance ever addressed by Irish laymen to their spiritual pastors and masters. It expresses the profoundest dissatisfaction with the curriculum marked out for the students of the university; setting forth the extraordinary fact that the lecture-list for the faculty of Science, published a month before they wrote, did not contain the name of a single professor of the Physical or Natural Sciences.

The memorialists forcibly deprecate this, and dwell upon the necessity of education in science: "The distinguishing mark of this age is its ardor for science. The natural sciences have, within the last fifty years, become the chiefest study in the world; they are in our time pursued with an activity unparalleled in the history of mankind. Scarce a year now passes without some discovery being made in these sciences which, as with the touch of a magician's wand, shivers to atoms theories formerly deemed unassailable. It is through the physical and natural sciences that the fiercest assaults are now made on our religion. No more deadly weapon is used against our faith than the facts incontestably proved by modern researches in science."

Such statements must be the reverse of comfortable to a number of gentlemen who, trained in the philosophy of Albertus Magnus and Thomas Aquinas, have been accustomed to the unquestioning submission of all other sciences to their divine science of Theology. But something more remains: "One thing seems certain," say the memorialists, viz., "that if chairs for the physical and natural sciences be not soon founded in the Catholic University, very many young men will have their faith exposed to dangers which the creation of a school of science in the university would defend them from. For our generation of Irish Catholics are writhing under the sense of their inferiority in science, and are determined that such inferiority shall not long continue; and so, if scientific training be unattainable at our university, they will seek it at Trinity, or at the Queen's Colleges, in not one of which is there a Catholic professor of science."

Those who imagined the Catholic University at Kensington to be due to the spontaneous recognition on the part of the Roman hierarchy of the intellectual needs of the age, will derive enlightenment from this, and still more from what follows; for the most formidable threat remains. To the picture of Catholic students seceding to Trinity and the Queen's Colleges, the memorialists add this darkest stroke of all: "They will, in the solitude of their own homes, unaided by any guiding advice, devour the works of Häckel, Darwin, Huxley, Tyndall, and Lyell; works innocuous if studied under a professor who would point out the difference between established facts and erroneous inferences, but which are calculated to sap the faith of a solitary student, deprived of a discriminating judgment to which he could refer for a solution of his difficulties."

In the light of the knowledge given by this courageous memorial, and of similar knowledge otherwise derived, the recent Catholic manifesto did not at all strike me as a chuckle over the mistake of a maladroit adversary, but rather as an evidence of profound uneasiness on the part of the cardinal, the archbishops, and the bishops who signed it. They acted toward it, however, with their accustomed practical wisdom. As one concession to the spirit which it embodied, the Catholic University at Kensington was brought forth, apparently as the effect of spontaneous inward force, and not of outward pressure which was rapidly becoming too formidable to be successfully opposed.

The memorialists point with bitterness to the fact that "the name of no Irish Catholic is known in connection with the physical and natural sciences." But this, they ought to know, is the complaint of free and cultivated minds wherever the priesthood exercises dominant power. Precisely the same complaint has been made with respect to the Catholics of Germany. The great national literature and scientific achievements of that country in modern times are almost wholly the work of Protestants; a vanishingly small fraction of it only being derived from members of the Roman Church, although the number of these in Germany is at least as great as that of the Protestants. "The question arises," says a writer in a German periodical, "what is the cause of a phenomenon so humiliating to the Catholics? It cannot be referred to want of natural endowment due to climate (for the Protestants of Southern Germany have contributed powerfully to the creations of the German intellect), but purely to outward circumstances. And these are readily discovered in the pressure exercised for centuries by the Jesuitical system, which has crushed out of Catholics every tendency to free mental productiveness." It is, indeed, in Catholic countries that the weight of ultramontanism has been most severely felt. It is in such countries that the very finest spirits, who have dared, without quitting their faith, to plead for freedom or reform, have suffered extinction. The extinction, however, was more apparent than real, and Hermes, Hirscher, and Günther, though individually broken and subdued, prepared the way in Bavaria for the persecuted but unflinching Frohschammer, for Döllinger, and for the remarkable liberal movement of which Döllinger is the head and guide.

Though managed and moulded for centuries to an obedience unparalleled in any other country, except Spain, the Irish intellect is beginning to show signs of independence, demanding a diet more suited to its years than the pabulum of the middle ages. As for the recent manifesto where pope, cardinal, archbishops, and bishops, may now be considered as united in one grand anathema, its character and fate are shadowed forth by the vision of Nebuchadnezzar, recorded in the Book of Daniel. It resembles the image, whose form was terrible, but the gold, and silver, and brass, and iron of which rested upon feet of clay. And a stone smote the feet of clay, and the iron, and the brass, and the silver, and the gold, were broken in pieces together, and became like the chaff of the summer threshing-floors, and the wind carried them away.

There is something in Jesuitism profoundly interesting, and at the same time clearly intelligible, to men of strong intellects and determined will. The weaker spirits, of whom there are many among us, it simply fascinates and subdues. From the study of his own inward forces, and their possible misapplication, the really determined man can understand how possible it is, having once chosen an aim, to reach it in defiance of every moral restraint—to trample under foot, by an obstinate effort of volition, the dictates of honesty, honor, mercy, and truth; and to pursue the desired end, if need be, through their destruction. This force of will, relentlessly applied, and working through submissive instruments, is the strength of Jesuitism.

Pure, honest fanaticism often adds itself to this force, and sometimes acts as its equivalent. Illustrations of this are not far to seek, for the dazzling prize of England, converted to the true faith, is sufficient to turn weak heads. When it is safely caged, it is interesting to watch the operations of this form of energy. In a sermon on the Perpetual Office of the Council of Trent, preached before the Right Reverend Fathers assembled in Synod, the Archbishop of Westminster has given us the following sample of it: "As the fourth century was glorious by the definition of the Godhead and the Consubstantial Son, and the fifth by that of his two perfect natures, and the thirteenth by that of the procession of the Holy Ghost, so the nineteenth will be glorious by the definition of the Immaculate Conception. Right Rev. Fathers," continues this heated proselyte, "you have to call the legionaries and the tribunes, the patricians and the people, of a conquering race, and to subdue, change, and transform them one by one to the likeness of the Son of God. Surely a soldier's eye and a soldier's heart would choose by intuition this field of England for the warfare of the faith. It is the head of Protestantism, the centre of its movements, and the stronghold of its powers. Weakened in England, it is paralyzed everywhere; conquered in England, it is conquered throughout the world. Once overthrown here, all is but a war of detail: it is the key of the whole position of modern error." This is the propaganda which England has to stem. What mere stubble a *dilettante* ritualist or a weak-headed nobleman must be when acted upon by this fiery breath of fanaticism! The only wonder is that weak heads, which are so assiduously and deliberately sought out, are not more plentiful than they are.

Monsignor Capel has recently been good enough to proclaim at once the friendliness of his Church toward true science, and her right to determine what true science is. Let us dwell for a moment on the historic proofs of her scientific competence. When Halley's comet appeared in 1456, it was regarded as the harbinger of God's vengeance, the dispenser of war, pestilence, and famine, and, by order of the pope, all the church-bells in Europe were rung to scare the monster away. An additional daily prayer was added to the supplications of the faithful. The comet in due time disappeared, and the faithful were comforted by the assurance that, as in previous instances relating to eclipses, droughts, and rains, so also as regards this "nefarious" comet, victory had been vouchsafed to the Church.

Both Pythagoras and Copernicus had taught the heliocentric doctrine—that the earth revolved round the sun. In the exercise of her right to determine what true science is, the Church, in the pontificate of Paul V., stepped in, and, by the mouth of the holy Congregation of the Index, delivered, on March 5, 1616, the following decree:

And whereas it hath also come to the knowledge of the said holy congregation that the false Pythagorean doctrine of the mobility of the earth and the immobility of the sum, entirely opposed to Holy Writ, which is taught by Nicolas Copernicus, is now published abroad and received by many—in order that this opinion may not further spread, to the damage of Catholic truth, it is ordered that this and all other books teaching the like doctrine be suspended, and by this decree they are all respectively suspended, forbidden, and condemned.

Though often quoted, I thought the never-dying flavor of this celebrated decree would not be disagreeable to some of my readers. It is pleasant to be able to say that the very doctrine here pronounced "false," "opposed to Holy Writ," and "damaging to Catholic truth," Science has persuaded even Monsignor Capel to accept.

But it is a constant *tendency* rather than a single fact which is chiefly important here, and a few jottings will show with sufficient plainness what this tendency has ever been. The fate of Giordano Bruno is referred to in my Belfast Address. For a further reference to him I would direct the reader to a brief passage in the Appendix to the same. The case of Galileo is also touched upon; and to this it may be added here that he died the prisoner of the Inquisition, which, true to its instincts, followed him beyond the grave, disputing his right to make a will, and denying him burial in consecrated ground.[1]

Again, the famous Academia del Cimento was established at Florence in 1657, and held its meetings in the ducal palace. It lasted ten years, and was then suppressed at the instance of the Papal Government. As an equivalent, the brother of the grand-duke was made a cardinal. The Jesuits were less successful in Bavaria in 1759; for they did their best, but vainly, to prevent the founding of the Academy of Sciences in Munich. Their waning power was indicated by this fact, and in 1773 Pope Clement XIV. dissolved the order. The decree was to be "irrevocable;" the Society of Jesus was "never to be restored;" still, in 1814, an infallible follower of Clement, Pope Pius VII., undid the work of his equally infallible predecessor, and revoked his decree.

But why go back to 1456? Far be it from me to charge by-gone sins upon Monsignor Capel's Church, were it not for her practices to-day. The most applauded dogmatist of the Jesuits is, I am informed, Perrone. Thirty editions of a work of his have been scattered abroad in all lands by a society to which he belongs. His notions of physical astronomy are quite in accordance with those of 1456. He teaches boldly that "God does not rule by universal law . . . . that when God [obviously a Big Man] orders a given planet to stand still he does not detract from any law passed by himself, but orders that planet to move round the sun for such and such a time, then to stand still, and then again to move, as his pleasure may be." Jesuitism proscribed Frohschammer for questioning its favorite dogma that every human soul was created by a direct supernatural act of God, and for asserting that man, body and soul, came from his parents. This is the society that now strives for universal power; it is from it, as Monsignor Capel graciously informs us, that we are to learn what is allowable in science and what is not!

In the face of such facts, which might be multiplied at will, it requires extraordinary bravery of mind, or a reliance upon public ignorance almost as extraordinary, to make the claims made by Monsignor Capel for his Church.

A German author, speaking of one who has had bitter experience

[1] Draper, "Trial of Galileo."

in this line, describes those Catholic writers who refuse to submit to the Congregation of the Index as outlawed; fair subjects for moral assassination.[1] This is very strong; and still, judging from my own small experience, not too strong. In reference to this point I would ask indulgence for a brief personal allusion here. It will serve a two-fold object, one of which will be manifest, the other being reserved for possible future reference. Sprung from a source to which the Bible was specially dear, my early training was confined almost exclusively to it. Born in Ireland, I, like my predecessors for many generations, was taught to hold my own against the Church of Rome. I had a father whose memory ought to be to me a stay, and an example of unbending rectitude and purity of life. The small stock to which he belonged were scattered with various fortunes along that eastern rim of Leinster, from Wexford upward, to which they crossed from the Bristol Channel. My father was the poorest of them. Still, in his socially low but mentally and morally independent position, by his own inner energies and affinities, he obtained a knowledge of history which would put mine to shame; while the whole of the controversy between Protestantism and Romanism was at his finger's ends. At the present moment the works and characters which occupied him come, as far-off recollections, to my mind: Claude and Bossuet, Chillingworth and Nott, Tillotson, Jeremy Taylor, Challoner and Milner, Pope and McGuire, and others whom I have forgotten, or whom it is needless to name. Still this man, so charged with the ammunition of controversy, was so respected by his Catholic fellow-townsmen, that they one and all put up their shutters when he died.

With such a preceptor, and with an hereditary interest in the papal controversy, I naturally mastered it. I did not confine myself to the Protestant statement of the question, but made myself also acquainted with the arguments of the Church of Rome. I remember to this hour the interest and surprise with which I read Challoner's "Catholic Christian Instructed," and on the border-line between boyhood and manhood I was to be found taking part in controversies in which the rival faiths were pitted against each other. I sometimes took the Catholic side, and gave my Protestant antagonist considerable trouble. The views of Irish Catholics became thus intimately known to me, and there was no doctrine of Protestantism which they more emphatically rejected, and the ascription of which to them they resented more warmly, than the doctrine of the pope's personal infallibility. Yet, in the face of this knowledge, it was obstinately asserted and reasserted in my presence some time ago, by a Catholic priest, that the doc-

[1] *See* the case of Frohschammer as sketched by a friend in the Preface to "Christenthum und die moderne Wissenschaft." His enemies contrived to take his bread, in great part, away, but they failed to subdue him, and not even the Pope's nuncio could prevent five hundred students of the University of Munich from signing an address to their professor.

trine of the infallibility of the pope had always been maintained in Ireland.[1]

But this is an episode, intended to disabuse those who, in this country or the United States, may have been misled in regard to the personal points referred to. I now return to the impersonal. The course of life upon earth, as far as Science can see, has been one of amelioration—a steady advance on the whole from the lower to the higher. The continued effort of animated Nature is to improve its conditions and raise itself to a loftier level. In man, improvement and amelioration depend largely upon the growth of conscious knowledge, by which the errors of ignorance are continually moulted and truth is organized. It is assuredly the advance of knowledge that has given a materialistic color to the philosophy of this age. Materialism is, therefore, not a thing to be mourned over, but to be honestly considered—accepted if it be wholly true, rejected if it be wholly false, wisely sifted and turned to account if it embrace a mixture of truth and error. Of late years the study of the nervous system and of its relation to thought and feeling has profoundly occupied inquiring minds. It is our duty not to shirk—it ought rather to be our privilege to accept—the established results of such inquiries, for here assuredly our ultimate weal depends upon our loyalty to the truth. Instructed as to the control which the nervous system exercises over man's moral and intellectual nature, we shall be better prepared, not only to mend their manifold defects, but also to strengthen and purify both. Is mind degraded by this recognition of its dependence? Assuredly not. Matter, on the contrary, is raised to the level it ought to occupy, and from which timid ignorance would remove it.

But the light is dawning, and it will become stronger as time goes on. Even the Brighton Congress affords evidence of this. From the manifold confusions of that assemblage my memory has rescued two items which it would fain preserve: the recognition of a relation between Health and Religion, and the address of the Rev. Harry Jones. Out of the conflict of vanities his words emerge fresh, healthy, and strong, because undrugged by dogma, coming directly from the warm brain of one who knows what practical truth means, and who has faith in its vitality and inherent power of propagation. I wonder is he less effectual in his ministry than his more embroidered colleagues? It surely behooves our teachers to come to some definite understanding as to this question of health: to see how, by inattention to it, we are defrauded, negatively, by the privation of that "sweetness and light" which is the natural concomitant of good health; positively, by the insertion into life of cynicism, ill-temper, and a thousand corroding

[1] On a memory which dates back to my fifteenth year, when I first read the discussion between Mr. Pope and Father McGuire, I should be inclined to rely for proof that the Catholic clergyman, in that discussion, and in the name of his Church, repudiated the doctrine of personal infallibility.

anxieties which good health would dissipate. We fear and scorn "materialism." But he who knew all about it, and could apply his knowledge, might become the preacher of a new gospel. Not, however, through the ecstatic moments of the individual does such knowledge come, but through the revelations of science, in connection with the history of mankind.

Why should the Roman Catholic Church call gluttony a mortal sin? Why should prayer and fasting occupy a place in the disciplines of a religion? What is the meaning of Luther's advice to the young clergyman who came to him, perplexed with the difficulty of predestination and election, if it be not that, in virtue of its action upon the brain, when wisely applied, there is moral and religious virtue even in a hydro-carbon? To use the old language, food and drink are creatures of God, and have therefore a spiritual value. The air of the Alps would be augmented tenfold in purifying power if this truth were recognized. Through our neglect of the monitions of a reasonable materialism we sin and suffer daily. I might here point to the train of deadly disorders over which science has given modern society such control—disclosing the lair of the material enemy, insuring his destruction, and thus preventing that moral squalor and hopelessness which habitually tread on the heels of epidemics in the case of the poor.

Rising to higher spheres, the visions of Swedenborg, and the ecstasy of Plotinus and Porphyry, are phases of that psychical condition, obviously connected with the nervous system and state of health, on which is based the Vedic doctrine of the absorption of the individual into the universal soul. Plotinus taught the devout how to pass into a condition of ecstasy. Porphyry complains of having been only once united to God in eighty-six years, while his master Plotinus had been so united six times in sixty years.[1] A friend who knew Wordsworth informs me that the poet, in some of his moods, was accustomed to seize hold of an external object to assure himself of his own bodily existence. The "entranced mind" of Mr. Page-Roberts, referred to so admiringly by the *Spectator*, is a similiar phenomenon. No one, I should say, has had a wider experience in this field than Mr. Emerson. As states of consciousness those phenomena have an undisputed reality, and a substantial identity. They are, however, connected with the most heterogeneous objective conceptions. Porphyry wrote against Christianity; Mr. Page-Roberts is a devout Christian. But notwithstanding the utter discordance of these objective conceptions, their subjective experiences are similar, because of the similarity of their finely-strung nervous organizations.

But, admitting the practical facts, and acting on them, there will always remain ample room for speculation. Take the argument of the Lucretian. As far as I am aware, not one of my assailants has attempted to answer it. Some of them, indeed, rejoice over the ability

[1] *See* Dr. Draper's important work, "Conflict between Religion and Science."

displayed by Bishop Butler in rolling back a difficulty on his opponent; and they even imagine that it is the bishop's own argument that is there employed. Instructed by self-knowledge, they can hardly credit me with the wish to state both sides of the question at issue, and to show, by a logic stronger than Butler ever used, the overthrow which awaits any doctrine of materialism which is based upon the definitions of matter habitually received. But the raising of a new difficulty does not abolish—does not even lessen—the old one, and the argument of the Lucretian remains untouched by any thing the bishop has said or can say.

And here it may be permitted me to add a word to an important controversy now going on. In an article on "Physics and Metaphysics," published in the *Saturday Review* more than fourteen years ago, I ventured to state thus the relation between physics and consciousness: "The philosophy of the future will assuredly take more account than that of the past of the relation of thought and feeling to physical processes; and it may be that the qualities of Mind will be studied through the organism as we now study the character of Force through the affections of ordinary matter. We believe that every thought and every feeling has its definite mechanical correlative in the nervous system—that it is accompanied by a certain separation and remarshaling of the atoms of the brain.

"This latter process is purely physical; and were the faculties we now possess sufficiently strengthened, without the creation of any new faculty, it would doubtless be within the range of our augmented powers to infer from the molecular state of the brain the character of the thought acting upon it, and, conversely, to infer from the thought the exact corresponding molecular condition of the brain. We do not say—and this, as will be seen, is all-important—that the inference here referred to would be an *a priori* one. What we say is, that by observing, with the faculties we assume, the state of the brain, and the associated mental affections, both might be so tabulated side by side, that if one were given, a mere reference to the table would declare the other.

"Given the masses of the planets and their distances asunder, and we can infer the perturbations consequent on their mutual attractions. Given the nature of a disturbance in water, air, or ether, and from the physical properties of the medium we can infer how its particles will be affected. The mind runs along the line of thought which connects the phenomena, and, from beginning to end, finds no break in the chain. But, when we endeavor to pass by a similar process from the phenomena of physics to those of thought, we meet a problem which transcends any conceivable expansion of the powers we now possess. We may think over the subject again and again—it eludes all intellectual presentation—we stand, at length, face to face with the Incomprehensible."

The discussion above referred to turns on the question: Do states of consciousness enter as links in the chain of antecedence and sequence which give rise to bodily actions and to other states of consciousness; or are they merely by-products, which are not essential to the physical processes going on in the brain? Now, it is perfectly certain that we have no power of imagining states of consciousness interposed between the molecules of the brain, and influencing the transference of motion among the molecules. The thought "eludes all mental presentation;" and hence the logic seems of iron strength which claims for the brain an automatic action, uninfluenced by states of consciousness. But it is, I believe, admitted by those who hold the automaton-theory that states of consciousness are *produced* by the marshaling of the molecules of the brain; and this production of consciousness by molecular motion is certainly quite as unthinkable as the production of molecular motion by consciousness. If, therefore, unthinkability be the proper test, we must equally reject both classes of phenomena. I, for my part, reject neither, and thus stand in the presence of two Incomprehensibles, instead of one Incomprehensible. While accepting fearlessly the facts of materialism dwelt upon in these pages, I bow my head in the dust before that mystery of the brain which has hitherto defied its own penetrative power, and which may ultimately resolve itself into a demonstrable impossibility of self-penetration.[1]

But, whatever be the fate of theory, the practical monitions are plain enough, which declare that on our dealings with matter depends our weal or woe, physical and moral. The state of mind which rebels against the recognition of the claims of "materialism" is not unknown to me. I can remember a time when I regarded my body as a weed, so much more highly did I prize the conscious strength and pleasure derived from moral and religious feeling, which, I may add, was mine without the intervention of dogma. The error was not an ignoble one, but this did not save it from the penalty attached to error. Saner knowledge taught me that the body is no weed, and that if it were treated as such it would infallibly avenge itself. Am I personally lowered by this change of front? Not so. Give me their health, and there is no spiritual experience of those earlier years—no resolve of duty, or work of mercy, no act of self-denial, no solemnity of thought, no joy in the life and aspects of Nature, that would not still be mine. And this without the least reference or regard to any purely personal reward or punishment looming in the future.

As I close these remarks, the latest melancholy wail of the Bishop of Peterborough reaches my ears. Notwithstanding all their "expansiveness," both he and his brother of Manchester appear, alas! to know as little of the things which belong to our peace as that wild ritualist who, a day or two ago, raised the cry of "excommunicated heretic!" against the Bishop of Natal. Happily we have among us

[1] *See* Tyndall's "Fragments of Science," article "Scientific Materialism."

our Jowetts and our Stanleys, not to mention other brave men, who see more clearly the character and magnitude of the coming struggle; and who believe undoubtingly that out of it the truths of science will emerge with healing in their wings. Such men must increase, if the vast material resources of the Church of England are not to fall into the hands of persons who may be classed under the respective heads of *weak* and *infatuated.*

And now I have to utter a "farewell," free from bitterness, to all my readers—thanking my friends for a sympathy more steadfast, I would fain believe, if less noisy, than the antipathy of my foes; commending to these, moreover, a passage from Bishop Butler, which they have either not read or failed to take to heart. "It seems," saith the bishop, "that men would be strangely headstrong and self-willed, and disposed to exert themselves with an impetuosity which would render society insupportable, and the living in it impracticable, were it not for some acquired moderation and self-government, some aptitude and readiness in restraining themselves, and concealing their sense of things." In this respect, at least, his grace the Archbishop of Canterbury has set a good example.

WATER-SUPPLY OF ISLANDS.

By FRANKLIN C. HILL.

ON islands of considerable size and height, composed of rocks and various earthy beds, springs of fresh water in the valleys are not uncommon, and their presence excites no remark. The rainfall of the island itself is laid up in its strata exactly as in the hills of the main-land, and the small size of the reservoir is made up for by the frequent rains and fogs to which islands are subject.

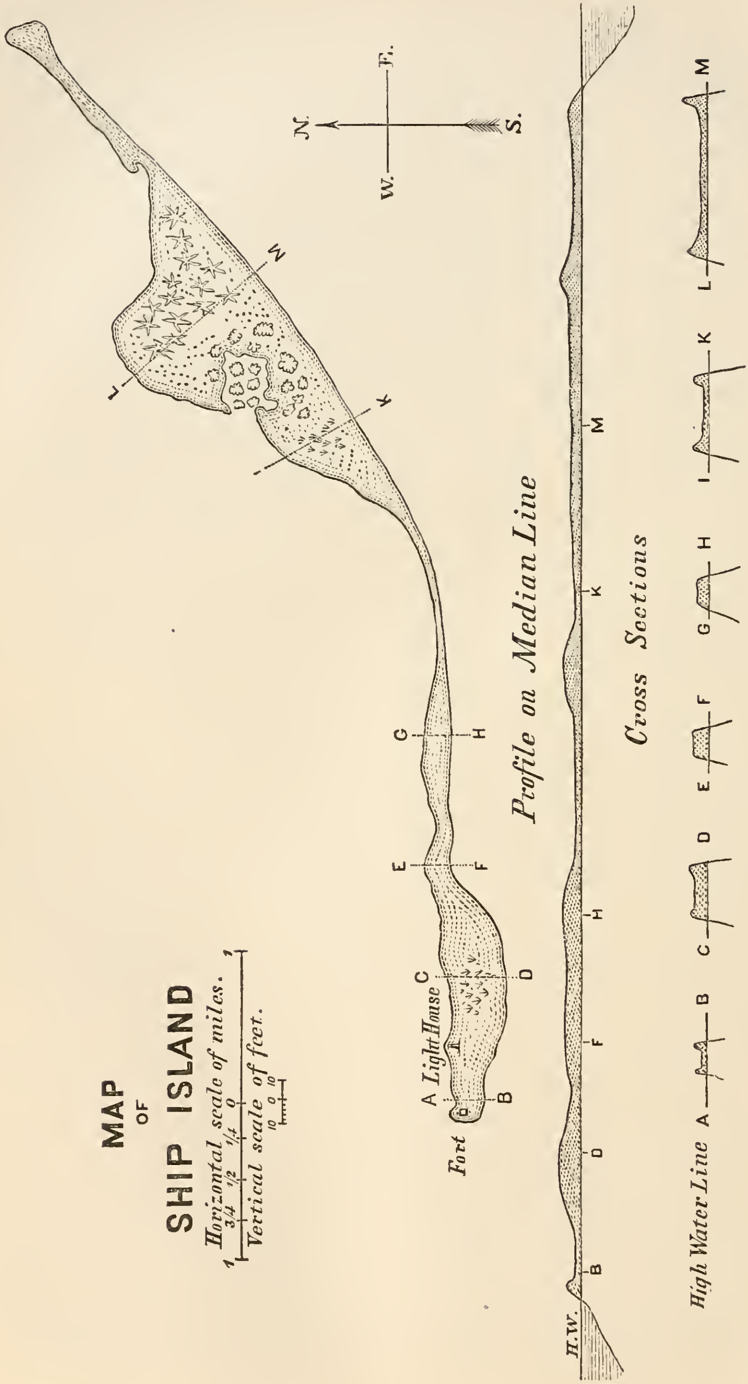
There are cases of islands near the main-land where springs are fed by streams from the continent following the rock-strata below the dividing straits. But on islands composed as many of those on our Southern coasts are, of pure sand and of very small elevation, and hence with no raised reservoir to supply springs, the fact that pure fresh water may be obtained in large quantities by digging, is a mystery even to many well-informed people, although the explanation is very simple. To say that the "sea-water filters through the sand into these wells and becomes as sweet and pure as spring-water," is simply to display profound ignorance of chemistry and facts.

From time immemorial the ash-leach has been in use in many civilized, that is, soap-making, countries. Essentially an ash-leach is a vessel tight enough to hold wood-ashes, but not tight enough to hold water. Being first filled with ashes, water is then poured in gradually, and, after a time, runs out below, highly charged with the soluble salt of the ashes.

But, although this machine has been so long in use, the principle on which it acts does not seem to have been fully understood until quite lately. About the year 1833 Messrs. Boullay, of Paris, applied the same apparatus to the manufacture of pharmaceutical preparations, tinctures, infusions, extracts, etc., and it at once became popular with pharmaceutists, under the name of Boullays' Filter, or the Displacement Apparatus. Its mode of operation is simple: the first portion of liquid poured in sinks into the powder that is to be exhausted, and saturates itself with the soluble parts of it. The later additions of liquid, instead of mixing with the first, drive it down before them and take its place, to yield it in turn to the next portions poured in. Thus the first portions of liquid that run from the bottom of the filter will, if it has been properly managed, contain nearly all the soluble matter, and the last will be almost unchanged. For example, if an ounce of powdered ginger be put into a glass tube, as a small lamp-chimney, over the lower end of which a piece of cotton cloth has been tied, and alcohol be slowly poured through it, the first fluid-ounce (f ℥ j) that comes through will contain about all the strength of the ginger. Looking through the glass, we can watch the whole process, see the first alcohol dissolve the resinous matter of the ginger, becoming thick and dark-colored in consequence, and then falling down before the new colorless alcohol added above.

Applying this principle of displacement to a sand-island, we have to start with a great heap of sand with its level or hollow top just above the reach of the waves, while the great mass of sand is below the sea-level. Of course all the submerged part is full of salt-water, while capillary attraction carries some of the water above the sea-level. The first rain that falls sinks at once into the loose sand. It rains very heavily in the gulf islands, but I never saw water run off of the surface; it sinks at once, and, in sinking, drives the salt-water before it, "displaces" it as the apothecaries say, but does not mix with it. Repeated rains continue the operation until there is a lake of fresh water held by the sand in the midst of the sea.

Fine sand will hold, between its grains, over one-third of its bulk of water; thus, within twelve feet of the sea-level, we have a lake of fresh water four feet deep, or about 1,250,000 gallons to each acre of island, and this is the supply reached by digging. But, should a long drought occur, evaporation would rapidly reduce the supply, and the sea-water following in will take its old place. Hence it was that, in 1864, we had plenty of good water at Ship Island and Santa Rosa, while at Brazos Santiago, where no rain had fallen, at the time of my visit, for ten months, the water was brackish and unfit for use, and the government was obliged to distill water from the sea for the use of the army, and the only vegetation on the island appeared to be


MAP
OF
SHIP ISLAND
Horizontal scale of miles.
1 3/4 1/2 1/4 0 1
Vertical scale of feet.
10 0 10
N.
S.
E.
W.
A Light House
Fort
Profile on Median Line
Cross Sections
H.W.
High Water Line

cactus and mesquite, showing that drought was not of rare occurrence there.

Our men encamped on Ship Island complained that the water in many of the wells which they dug soon became bad. Perhaps this was owing to the surface-water of the swamps getting into them, or perhaps the drainage of the camps. Those who know the habits of our men in camp can judge for themselves.

A glance at the map and profiles of Ship Island will show how admirably the island is adapted to collecting and holding rain-water. The broader parts of the island are completely surrounded by a raised beach, making large basins. The basin west of the lighthouse is comparatively new. All the islands in that chain grow at their western ends and wash away on the east. The only vegetation in this western basin was, at the time of my sojourn there, a few low, creeping herbs. The beach was so low that a heavy September gale blew the waves over it, and the whole basin became a salt lake, around which I walked the next day on the beach. The sea having by that time fallen rather below its usual height, there was a difference of several feet between it and the surface of the lake. Observing that at one place the water was just level with the top of the beach, I scratched a shallow channel across it with a stick. In five minutes a strong brook was running out, and, in ten more, a roaring river. This part of the island being subject to such overflows, of course no wells are sunk in it. The fort depends on cisterns of rain-water; but it would be easy to run a pipe underground to a well above the lighthouse and get plenty of water.

The basin east of the lighthouse was a swamp in my time, thickly overgrown with grasses. Afterward, the commandant had it ploughed and made into a garden, said to have been very productive, especially in melons. The neck, of course, was barren, shifting sand, while the large basin beyond was not only swampy, but had a fresh pond in it. The drier parts were covered with a beautiful purple-topped grass, and had some showy flowers; while the wetter parts, and even the pond, were thickly set with woody shrubs of considerable size, and the wide, shallow mouth of the pond was so obstructed by them that the quiet waters of the Mississippi Sound never penetrated it. Beyond the pond were formerly some live-oaks and pines; but the oaks had all been cut down, and the pines were rapidly following them, being carried off for fuel by the prison-camp near the light-house. All around this end of the island, stumps and dead trees standing far out in the water showed that the sand was being gradually swept away by the waves.

Santa Rosa is Ship Island on a larger scale. It has several fresh-water ponds, and many bushes and trees. On its barren western end I obtained an abundance of good water by sinking a well some four or five feet. The wooden curb was built larger at the bottom, and set in a shallow pit scooped in the sand. A man was then put inside to shovel out the sand, and, as he dug, the curb sank around him. Presently he was waist-deep in water, and the well was finished and yielded freely all summer.

MAREY'S NEW RESULTS IN ANIMAL MOVEMENTS.

By Prof. ALFRED M. MAYER,
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THE publication of Marey's "Animal Mechanism" in the "International Scientific Series" has put the general reader in possession of one of the most interesting works ever published on experimental physiology. The simplicity and precision of the author's experimental methods, his conscientiousness in being sure of one step before he takes the next, and the skill displayed in interpreting and combining his experimental results—all these admirable characteristics have rendered his book instructive and entertaining to those who merely follow from afar the progress of science, while, at the same time, he has furnished a model of precise research and clear exposition to the professed scientist.

Marey arrives at his facts *directly*, not *inferentially*, and this is the charm of his book. The mind of the reader does not rest on the fallible judgment or mere opinion of the author, but is brought face to face with the very records made by the phenomena themselves.

In studying the progress of science, one cannot help remarking certain periods of sudden acceleration in the progress of discovery. These periods of unusual activity are not always, but certainly are very often, due to the invention of some precise and readily-applicable instrument, which gives, as it were, a new scientific sense, and brings into the range of our intellectual vision phenomena and numbers whose existence were barely suspected, until revealed by the aid of some comparatively simple contrivance. Such epochs of sudden progress followed the inventions of the telescope, the spectroscope, the ophthalmoscope, the galvanometer, and the tuning-fork chronoscope. For the latter instrument, men of science are indebted to Dr. Thomas Young, that wonderful man, who touched no department of knowledge that he did not adorn. The application of the sinuous traces of a vibrating tuning-fork on a rolling cylinder, to divide a second of time into as many parts as the number of times the fork swings to and fro in a second, was described by Young in 1807, and published in his "Lectures on Natural Philosophy and the Mechanical Arts," vol. i., p. 191. Like Young's discoveries of the theory of colors, and of the undulatory theory of light, this beautiful invention laid fallow for many years, until reinvented in 1840 by Duhamel, and subsequently brought into general use in physics and physiology. It is now the essential element of the chronoscopes, or, more accurately speaking, of the *chronometers*, used to measure the velocities of projectiles, and to solve such problems as the rates of progress of the nervous influence and of the muscular wave.

To make any tuning-fork a chronoscope, it is only necessary to know the number of vibrations which the fork makes in a second at a known temperature. This number is determined to the last degree of precision by the following method, devised by the author of this article: A break-circuit clock is placed in the primary or battery circuit of an induction-coil; while one terminal wire of the secondary coil is connected with a metallic cylinder covered with smoked paper, the other terminal wire is led to the tuning-fork, which traces its vibrations, by means of a delicate metallic point, on the paper-covered cylinder. At each second the break-circuit clock sends a spark from the point attached to the vibrating fork, through the smoked paper to the metallic cylinder. It is evident that, on counting the number of sinuosities made by the vibrating fork between two contiguous spark-holes, we have the number of vibrations per second made by the fork. After the above determination has been made, the tuning-fork becomes the most accurate and uniformly rated chronometer yet devised by men of science. But the time-recording tuning-fork is only one part of the apparatus required in the study of physiological motions. We must also be in possession of some contrivance which can be readily applied to an organ, the durations and varied velocities of whose motions we would study, and this contrivance must make a graphic record of these motions alongside of the time-record drawn by the tuning-fork. To Marey we are indebted for many effective recording instruments, but the apparatus which he has most extensively used, and which is admirably adapted to the study of the motions in some of the vital functions and in locomotion, consists of a small drum of shallow depth, one of whose ends is covered with an elastic membrane. The interior of this drum is connected with the interior of a similar drum by a rubber tube of very small internal diameter. The membrane of one of these drums presses against the surface whose motions we would study. A delicate lever rests on the membrane of the other drum, and the end of this lever is armed with a delicate point which touches a revolving cylinder covered with smoked paper. On this cylinder the tuning-fork also simultaneously traces its time-record. Now, as both drums, and the tube which connects them, form an air-tight space, it follows that any depression, given to the membrane which touches the moving surface, will compress the air in this drum, in the connecting tube, and in the drum which carries the delicate lever. The membrane of the latter drum will move outward and cause the pointed lever to move and make its trace on the revolving cylinder. Of course an elevation of the membrane in the first drum will cause a depression in the membrane of the second drum, accompanied by a movement of the lever opposite to that described above. Thus the lever records accurately every movement of the membrane of the distant drum, and the intervening flexible tube allows one to attach the drum to the limb of a moving man, or quadruped, to the wing of a flying-bird, or to the chest, to obtain the traces of the motions of the lungs and of the heart.

In 1863 Marey first began to apply the graphic method to biological studies, in his "Physiologie médicale de la Circulation du Sang." In 1868 he published his "Du Mouvement dans les Fonctions de la Vie." In the preface of this truly valuable work he says: "By the use of the graphic method the illusions of the observer, the tediousness of descriptions, and the confusion of facts, disappear. These two ruling qualities, clearness and conciseness, become every day more desirable, by reason of the enormous increase in biological publications." In his last work, "Animal Mechanism," he has illustrated this remark; for surely no "tediousness" will be experienced in the perusal of this work, in which we are taught, with such "clearness and conciseness," how men and quadrupeds walk and run, and how birds and insects fly.

The desire to see Marey's work on Animal Mechanism fully appreciated by the public has induced us to put the reader in possession of his quite recent discoveries, which could not be incorporated in the book published in the "International Series." We refer to two of his most important researches, one on "Human Locomotion," taken from the *Comptes Rendus*, of July 13, 1874; the other, "On the Resistance of the Air under the Wing of a Bird during its Flight," we take from the *Journal de Physique* of July, 1874.

I. New Experiments on Human Locomotion.—The brothers Weber believed that in human locomotion the oscillation of the leg in walking was due alone to the action of gravity; this is to say, that the foot, while off the ground, has the motion of a pendulum. For a long time this opinion has held its place in physiology, but it has been opposed, in recent years, by arguments of various kinds. First, by M. Duchenne, of Boulogne, who showed that the leg is not entirely passive during its displacement, for certain muscular paralyses prevent its oscillation; M. Giraud-Teulon has attacked the theory of Weber, by showing the mathematical errors on which it is founded; and, finally, M. Carlet has determined, experimentally, the active function of certain muscles in the displacement of the leg during walking.

If gravity does not alone act in producing the oscillation of the leg, it becomes impossible to foresee what motion will result from its combination with muscular action. I have appealed to the graphic method for the experimental answer to this question.

When a body moves in a straight line, with variable velocities at each instant, it is easy to obtain the graphic representation of its motion, provided the space moved over is not too extensive. It suffices to join the body, by means of a rigid connection, with a writing-lever, which touches a revolving cylinder, covered with smoked paper. The tracer on the writing-lever, moved with variable velocities, and in a direction parallel to the axis of the cylinder, will draw sinuous curves, whose parts will indicate by their inclination the velocities of the motions which produced them.

But the motions in walking are too extended to be traced on the revolving cylinder in their real magnitudes; in order to reduce them, while at the same time I preserved their characteristics unaltered, I had recourse to a train of wheel-work. In this apparatus, each wheel working into another, whose teeth are ten times more numerous than those of the former, it follows that the motion communicated to the first axis will be reproduced by the second with a reduction of $\frac{1}{10}$; the third axis will reproduce the motion reduced to $\frac{1}{100}$; and the fourth axis will reduce it to $\frac{1}{1000}$, etc.

If we attach to the foot of a walker a thread, which is wrapped around the wheel on the first axle of the wheel-work, and if to the third axle we connect the writing-lever, we can obtain traces on the revolving cylinder which will have only $\frac{1}{100}$th of the extent of the paths gone over by the foot of the walker.

Fig. 1 shows five traces obtained from the foot when walking with various velocities. *A* has been produced by the slowest walk; *B* is the ordinary gait; while *C* is the most rapid: the remaining traces have been obtained from gaits less rapid than that of *C*.

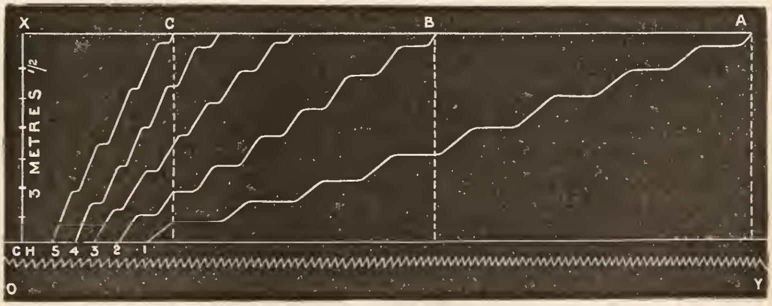

FIG. 1.

(The figure represents the smoked paper, unrolled from the revolving cylinder after the experiment. The paper revolved with the cylinder in the direction from *O* to *Y*. Therefore, the axis of the cylinder was parallel to *OX*, and the tracer on the writing-lever moved parallel to *OX*. It follows that, if the foot had remained stationary while the cylinder revolved, the tracer would have described a straight line parallel to *OY*. *CH* is the trace of the vibrating tuning-fork; each bend of its sinuous line is equal to $\frac{1}{10}$th of a second of time. This chronographic trace gives us the means of estimating accurately the duration of each step and the velocity of the foot at each instant while it is swinging in the air. The spaces gone over by the tracer, as before stated, are $\frac{1}{100}$th of the real distances traversed by the foot; that is, one centimetre on the paper equals one metre gone over by the foot.) Hence, every thing relative to the transport of the foot in walking is expressed in this figure.

1. *Velocity of the Gait.*—This is expressed by the general inclination of the curve, or by the relation existing between the lengths parallel to OX and to OY. As the different traces contained in the figure correspond to the same distance (three metres and a half; marked on the left-hand vertical line of the figure) gone over in variable times, it follows that the relation of these times to this distance will give the velocities of the different gaits. If we count on the chronograph-trace the time included between the beginning of each curve, and its termination in the line A, B, C, we shall have the measure of this time. (For example, the time occupied in going over $3\frac{1}{4}$ metres with the gait B is given by counting the bends of the tuning-fork trace contained between 2 and the perpendicular line let fall from B on to the chronograph-trace.) Thus, for the slow walk from 1 to A, we count thirteen seconds; the more rapid walk from 2 to B occupied six and a half seconds; while with the rapid gait the distance from 5 to C was traversed in two seconds.

2. *Alternate Periods of Rest and of Motion of the Foot.*—It is evident that, whenever the traces show an horizontal line (that is, a line parallel to OY), those portions of the traces correspond to the traces made while the foot touched the ground and was immovable, since the spaces then gone over are nothing. The traces show that the duration of the periods of repose decreases as the gait is accelerated. The time during which the foot is in motion is shown by the oblique lines whose projection on the trace of the chronograph increases, relatively to the periods of repose, as the gait is more rapid. This proves that the length of the step increases with the velocity of the gait.

We can also, from the traces, estimate with precision the relation of the velocity of gait to the length of step, the relative variations of the duration of the periods of repose and of motion of the foot, etc.; but we will not here dwell on these details; the essential point under consideration is the following:

3. *The Nature of the Movement of Translation of the Foot.*—The trace of this movement is shown in a line which is nearly straight in all of its parts; the motion of the foot is therefore uniform during nearly the whole of its translation; the inflections of the line at its beginning and at its end show that, in rapid gaits especially, the motion of the foot begins and ends in short periods of variable velocities. From the above we are now able to judge how far the oscillation of the leg is analogous to that of a pendulum.

But we must not exclusively attribute to the action of the muscles of the leg this uniformity in the translation of the foot. In fact, we know that, during this translation, two distinct causes are working:

1. The angular movement which the leg has around the pelvis.
2. The horizontal translation of the pelvis itself; that is to say, of the point of suspension of the leg while the latter oscillates.

We may conceive that, by the combination of these two movements, the motion of the leg may tend to become uniform; this will happen if the minima of the velocities due to the first-named species of motion correspond with the maxima of the second kind of motion. It therefore becomes very interesting to determine what is really the motion of the trunk of the body during different gaits.

The apparatus already described has also served for the solution of this problem.

A cord attached to the waist transmitted to the registering apparatus the motion of translation of the trunk. By experimenting successively on various gaits, we obtained the following figure, whose analysis gives some interesting results:

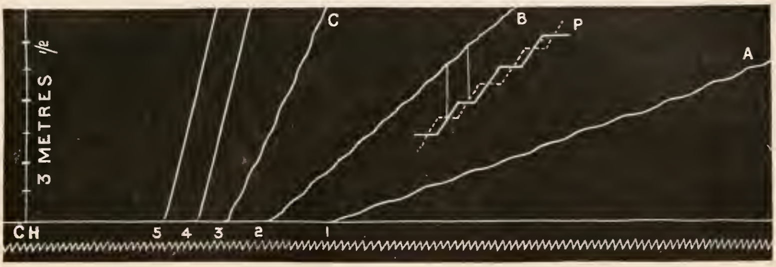

Fig. 2.

The undulations are far greater when the walking is very slow than when it is more rapid. Thus, the motion of the body becomes more uniform by reason of a higher velocity. This is the reverse of what happens with the vertical oscillations of the body, which increase with the velocity of progression and with an increase in the length of the steps.

The number of alternations of motion is double that produced by the movement of a single foot, as shown in Fig. 1. This is readily understood when it is remembered that the two feet, repeating the same acts, give alternately to the body a new impulsion.

To make clear this action we have traced, parallel to the line 2 of Fig. 2, the curves *P*, produced by the motions of the right and of the left foot. These curves, of which one is dotted, and the other full, are at once recognized as similar to those of the line 2 *B*, of Fig. 1. In fact, on observing the superposition of the different parts of these curves with the curve of translation, we see that the body receives an increase of velocity about the middle of the period when either foot is on the ground. This fact is in harmony with experiments which I have already published.

I will add, in concluding, that one of the most important results obtained by these researches is, the idea which they give of the variability of the movement of translation of the body during walking and running.

In another publication I shall show the applications which can be deduced from these studies to the best utilization of the work of animals.

II. On the Resistance of the Air to the Wings of a Bird during its Flight.—I have presented to the Academy of Sciences a memoir which proves that the wings of a bird, during their downward movements, meet with more resistance from the air when the bird has an horizontal motion of progression than when the bird, depressing his wings with the same velocity, has no horizontal motion of translation.

The explanation of this phenomenon appears to me to be as follows: a wing, or any surface whatever, which moves against the air, meets, at the beginning of its motion, a considerable resistance, on account of the inertia of the air, which resists every displacement; but, little by little, the air yields, and the velocity of its motion gradually increases, until it may equal that of the moving surface which displaces it; this phase of motion having been reached, the resistance diminishes. Finally, when the moving body stops, the moving air tends to continue its journey, and it thereby produces before the moving surface a true *aspiration*, or negative pressure. But a bird, which moves horizontally during the depressions of its wings, acts, during successive instants of that depression, on a series of columns of air over which it passes. From each column it meets with that maximum resistance which the inertia of the air presents at the first instants of the action of the wing. Finally, when the wing has reached the lowest point of its depression, it is not over the mass of air which it has just set in motion, because the motion of translation of the bird continually brings it into regions where the air is at rest. All of these conditions are evidently favorable to flight, since they increase the resistance of the air, which alone furnishes to the bird its support, and the reaction to its moving wing.

To prove the exactness of this theory, I have made certain experiments in which a uniform quantity of work was applied to produce the elevation and depression of the wings of an artificial bird. In some experiments the motions of the wings took place while the machine was stationary; they had a great amplitude of motion. In other experiments we gave the artificial bird a motion of translation, and then we observed that the amplitude of the flaps of the wing diminished considerably, which fact showed an increase in the resistance of the air.

MM. Planavergne claim the priority of the theoretic idea which I have enunciated, and show, in fact, that they had published, some years since, a memoir, in which this theory is explicitly stated. However, these authors have furnished no experimental demonstrations of their views; consequently, it has appeared to me that it would be interesting to continue the researches which I had begun, and to determine, as accurately as possible, on one hand, the phases and variable conditions of the resistance of the air to a moving body which displaces it with a uniform motion; on the other hand, to find the increase of the resistance of the air under the wings of an apparatus which is transported with determinate velocities.

First Series of Experiments.—*Determination of the variable and constant resistances opposed by the air to a moving body which displaces the air with a uniform motion.*

In a solid framework, which glides easily on an horizontal plane, I placed a light screen, with its plane vertical and perpendicular to the direction of its motion. This screen turns around an horizontal axis; and an arm attached to it is charged with an additional weight until perfect equilibrium is established between the arm and the screen itself. This having been done, we have no fear of the inertia of one or another part of the system causing the screen to revolve around its axis at the beginning of its motion of translation. If such a movement of rotation does take place, we must attribute it to the resistance offered by the air.

Behind the screen is placed a little manometric apparatus, which communicates, by means of a tube, with a drum, having a lever resting on its membrane.[1]

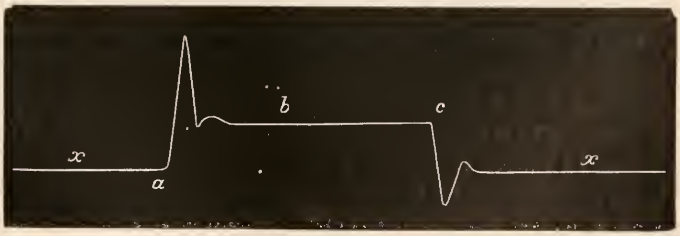

Fig. 3.

The apparatus having been thus arranged, we give to it a uniform motion of translation which lasts half or a quarter of a second, and we obtain on a revolving cylinder the above trace of the point of the writing-lever attached to the membrane of the recording drum.

When the screen is at rest, the apparatus traces an horizontal line

[1] For a description of Marey's manometric apparatus, the reader is referred to "Animal Mechanism," published in the "International Scientific Series."

x x, which corresponds to the zero of pressure on the dynamometer. At the instant of the beginning of the translation the apparatus shows an energetic pressure (*a*) on the dynamometer; this is the initial variable resistance caused by the inertia of the air against which the screen pushed. Very soon afterward the curve falls, announcing that the resistance of the air has diminished, although the motion of the disk had remained uniform. This is owing to the fact that the air had then partly acquired the motion of the screen. The pressure falls thus to the level *b*, which marks the constant resistance of the air during the whole remaining period of the translation.

Finally, when the apparatus is suddenly stopped, we see that the trace of the recording-lever is suddenly depressed at the point *c;* this is due to the variable terminal condition: it consists in the carrying of the screen forward by the column of air already set in motion by it. This negative resistance gradually ceases, and the tracer returns to *zero.*

We were not able to determine with this rough apparatus the absolute value of the resistance of the air corresponding to different instants of uniform translation, but we can readily see that there exist two variable states, of which one precedes and the other follows the constant resistance of the air. The studies of physicists have heretofore been directed only to the determination of the constant resistance corresponding to different velocities.

SECOND SERIES OF EXPERIMENTS.—*Increase of the resistance of the air to the downward movement of the wing of a bird, caused by the horizontal translation of the bird.*

In making the above determination, I have roughly imitated the construction of the bird, by reducing each of the wings to a thin and rigid plane of $\frac{1}{2}$ a metre in length, and $\frac{1}{10}$ a metre in breadth. These two wings are simultaneously depressed by the action of a spring.

A constant amount of work is thus employed for each blow of the wings. The translation of the artificial bird takes place in gliding along an horizontally-stretched iron wire. Two large wheels, one of them furnished with a crank-handle, move an endless cord parallel to the iron wire. The apparatus with wings is attached to this cord, and can thus be moved horizontally with greater or less velocities.

It is now necessary to determine with precision the velocity of translation and the duration of the depression of the wings. The graphic method gives readily these two measurements:

1. *Measurement of the Velocities of Translation of the Apparatus.*—This velocity is evidently the velocity of a point on the endless cord, to which the winged apparatus is attached. This cord passes around a little pulley, whose revolutions are counted and registered on a revolving cylinder by means of a lever which is worked pretty much as the lever in the registering apparatus of Morse's telegraph.

The little pulley which serves to measure the velocities is exactly

$\frac{4}{10}$ of a metre in circumference; one-half of its circumference is covered with a metallic band, the other half is formed of insulating material. Metallic springs press against the periphery of the pulley, so that, while they touch the metallic band, a current from a battery depresses the lever which traces on the revolving cylinder. Hence the lever is depressed, while $\frac{2}{10}$ of a metre of the cord pass, and it is elevated during the next $\frac{2}{10}$ of a metre of passage of the cord. Thus are registered, in an indented line, the velocities of translation of the artificial bird. Evidently the greater the velocity of the bird the greater will be the number of indentations inscribed in a second on the uniformly-revolving cylinder.

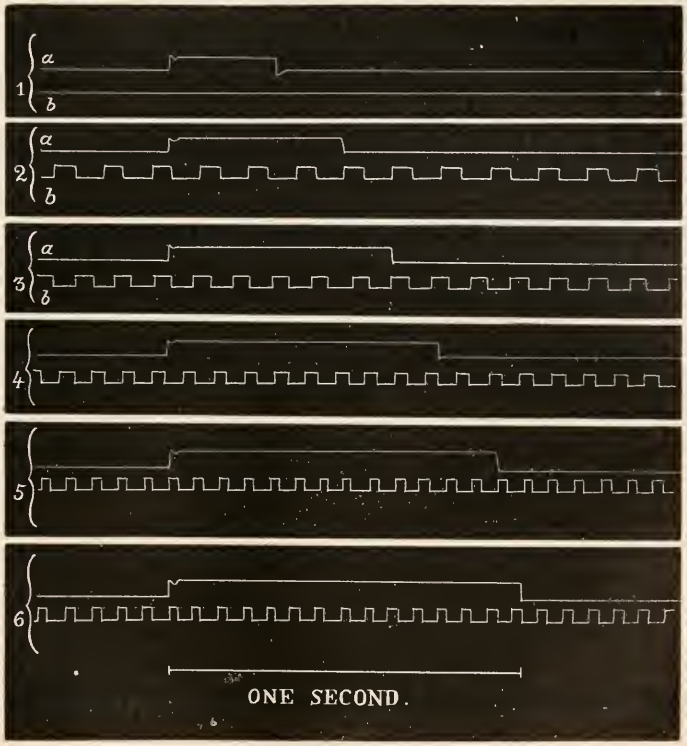

Fig. 4.

2. *Measurement of the Duration of the Depression of the Wings.*—A second electrical recorder, similar to that which registers the turns of the pulley, serves to determine the duration of the depression of the wings. For this purpose it is necessary that, at the beginning of the depression, the current of a battery should be broken, and this action is registered on the revolving cylinder by an indentation in the trace of the writing-lever; also, at the end of the depression of the wings, the current must be closed again, and this instant is likewise registered on the cylinder.

We have thus obtained simultaneously the traces of the velocities of translation of the artificial bird, and the durations of the depressions of its wings, and we have obtained a series of determinations of which the preceding figure (4) furnishes some examples:

Experiment No. 1.—The upward indentation in the line *a* shows the duration of the depression of the wings. Taking that length on the scale of time, we see that the downward movement of the wing lasted less than $\frac{1}{3}$ of a second. In that experiment there was no translation of the bird. The line *b* does not show any indentation.

Experiment No. 2.—The duration of the depression of the wings (line *a*) is already greater; it exceeds one-half of a second. The translation was then nearly three metres per second. We find this by taking in the dividers the length on the line *b* of the $3\frac{1}{2}$ double indentations of the tracer, which show that $3\frac{1}{2}$ times $\frac{4}{10}$ of a metre, or 1.4 metre, have been traversed by the artificial bird. We carry this length to the scale of time, and we find that it is contained about twice in a second. We thus see at once that the duration of the downward motion of the wing increases with the velocity of translation of the artificial bird.

Experiments Nos. 3–6.—In the remaining experiments, proceeding as we have already done, we find that the duration of the depression of the wing increases with the velocity of translation, and that with a velocity of $5\frac{1}{2}$ metres the downward movement of the wing lasts about one second. I have not been able to find the accurate relation between the velocity of translation and the duration of the downward motion of the wing. Experiments made in precisely the same conditions sometimes present slight differences, which are due to the fact that the slightest oscillation of the iron wire, which serves as a support and guide for the artificial bird, slightly changes the durations of the phenomena. From the first series of experiments, it would appear that the duration of the depression of the wing increases in proportion to the velocity of its translation, at least within the limits of the velocities with which I have experimented.

THE RELATIONS OF WOMEN TO THE PROFESSIONS AND SKILLED LABOR.

By ELY VAN DE WARKER, M. D.

THERE are fields of labor in which women have been immemorially active. In all matters relating to the cares of the house and children among the civilized, and, among the barbarous and the lowest strata of life in Europe and elsewhere, field-labor, the care of animals, and the lighter manufactures, are the tasks imposed upon women.

Deduct from this the comparatively small number of women of fashion whose existence is merged into the decorative part of social life, and we have here roughly grouped the lines which have defined the usefulness of women, and which have lain parallel for ages. In the midst of this toiling mass of humanity phenomenal women have appeared — women who have thrown down the dividing lines of prejudice, and created for themselves places among the most celebrated of the other sex. Those who have thus elevated themselves above the mass have demonstrated the capacity of women not only for the highest culture, but also their ability to equal men in the use of faculties which are their most distinguished attributes.

For a generation or more the question of woman's entry into employments deemed man's exclusive province has attracted attention, and raised up for woman a body of aggressive advocates of both sexes, who, by their demands, have provoked some harsh criticism from those who are in no sense the enemies of the intellectual and worldly advancement of women. Woman is now submitting her fitness to find employment, in the learned professions and skilled labor, to the rigid test of actual trial. Will she succeed, or will those of her sex, who achieve success in these fields of labor, be the exception, rather than the rule, in the future as in the past? In order to answer this question, it is my purpose to study woman in this relation, as a gynæcologist,[1] leaving out of consideration the social aspects of the case. One, who has devoted years to the study of women and their diseases, has a right to be heard upon this vital question. I do so the more readily because I know of no gynæcologist who has devoted his special learning to the study of woman's relation to man's work as a means of subsistence and of usefulness. For our purpose, therefore, woman must be scientifically investigated as a means to the accomplishment of certain ends. She must be studied rather in her physical and mental fitness, than in relation to society in her new position. This latter part of the subject belongs to the sociologist.

An examination of the present relation of woman to the other sex will throw light upon the complex problem of her success, in the future, in these fields of usefulness. The women of savage races, except sexually, present but slight differences in physical development and mental character from the males. That they are in base servitude to the other sex is in obedience to the aggressive and belligerent character of all males of the higher order of animals. This has the force of a law. The moral subjection of woman to the other sex is fundamentally a sexual peculiarity. With the slow advent of civilization the differences between the sexes increased. With no lessening of subjugation the capacity of woman for gross labor decreased, and from man's equal, physically, she became only his equal mentally. The chivalry of the middle ages of Europe kept viable the principle

[1] Gynæcology, that branch of pathology which treats of the diseases of women.

of her social equality, which she had wrung from man during the period of classic civilization. Of all things, mediæval woman alone did not retrograde. I believe the modern woman to be the natural outgrowth of the woman of chivalry.

And here let me apply to this question the laws of heredity and sexual selection. These laws touch the human family with as much force as the lower forms of animal life. The fact that man is marked by intellectual power in no way exempts him from the operation of the fundamental laws of biology. Objections which, at the first glance, may appear to be well taken against applying these laws to explain the existing relation of women to the other sex, become of small moment when we consider that, in his sexual relations, man approximates to nearly the level of the lower animals. M. Quetelet, who has made this a special study, remarks as follows: "It is curious to see man, proudly entitling himself King of Nature, and fancying himself controlling all things by his free-will, yet submitting, unknown to himself, more rigorously than any other being in creation, to the laws he is under subjection to."[1] Mr. Buckle, in the introduction to his "History of Civilization," carries the argument of Quetelet to even a greater extent. I think this will satisfy any possible objection to the propriety of applying these laws to the exposition of my subject.

Whatever may be woman's fitness in the future to become man's peer in the professions and skilled labor, there is this fact against her in the present: she is laboring under the accumulated inherited tendency of countless generations. That which had its origin in common with sister animals in physical and moral subjection to the male, has, in spite of the operation of that intellectual force which we see operating so potently at the present day to cast off this subjugation, continued in full force. I can explain this in no other way except as the result of heredity. This position of woman is as clearly a sexual trait as in lower animals. Darwin says that, "as peculiarities often appear in one sex, and become hereditarily attached to that sex, the same fact probably occurs under nature, and, if so, natural selection will be able to modify one sex in its functional relation to the other sex."[2] Dr. Maudsley, in speaking of one relation of woman to man, says: "Through generations her character has been formed with that chief aim (marriage); it has been made feeble by long habits of dependence; by the circumstances of her position, the sexual life has been undesignedly developed at the expense of the intellectual."[3] Mr. Herbert Spencer insists upon this. "Certain powers which mankind have gained in the course of civilization cannot, I think, be accounted for, without admitting the inheritance of acquired modifications."[4]

[1] Popular Science Monthly, vol. ii., p. 46.
[2] "The Origin of Species," p. 83.
[3] "The Physiology and Pathology of the Mind," p. 203.
[4] "Principles of Biology," vol. ii., p. 249.

The law of sexual selection also comes in as a factor to account for the present relation of the sexes. Since our modern civilization there have ever been women who aimed to relieve their sex of their dependent relation to man. With this moral force ceaselessly antagonizing the natural relation of the sexes and the forces of heredity, why has it not, in a more marked degree, accomplished the noble purpose at which the more intellectual and stronger minds of the sex have aimed ? To offer a reasonable explanation of this, I apply the law of sexual selection. Men and women do not appear to wed out of free choice, but in obedience to law which finds its expression in individual preferences. This, in the human family, may be called sexual selection. Mr. Walker states it in this way: "Love from a man toward a masculine woman would be felt by him as an unnatural association with one of his own sex; and an effeminate man is equally repugnant to woman. In the vital system, the dry seek the humid; the meagre, the plump; the hard, the softer; the rough, the smoother; the warmer, the colder; the dark, the fairer, etc., upon the same principles; and so, also, if here any of the more usual sexual qualities are reversed, the opposite ones will be accepted or sought for."[1] Dr. Ryan, in speaking of selection in relation to marriage, uses nearly identical language.[2]

The annals of literature show that the most eminent of the sex either are unmarried, or are married late in life, and are thus often without issue. The women who intellectually leave their impress upon the age in which they live are the very class to which this law of sexual selection applies. The chances of this order of women leaving daughters who will inherit their superior mental vigor are greatly inferior to those of the average woman. The woman of the average, her mind and ambition being of the measure of the ordinary matters of life, not only seeks a husband by the force of education, but is sought by men. Thus, married early in life, she becomes the source from which the population is recruited. This, in my judgment, is not only a potent cause of the present relation of the sexes, but will serve to explain the chances of women becoming prominent in the professions of the future.

There is another set of laws which apply to this part of the subject. These are the phenomena which are observed in studying human increase, and are called the laws of population. The forces engaged in the evolution of nervous and mental (cerebral) structure are opposed to those necessary to reproduction. Mr. Herbert Spencer expresses it as an antagonism between Individuation and Genesis; and that this antagonism is more marked " where the nervous system is concerned, because of the costliness of nervous structure and function."[3] There is no part of individuation so costly as that of cerebral growth. The more solid expansion of mind is accomplished after general structural

[1] " Intermarriage," by Alexander Walker, 1839, p. 116.

[2] " The Philosophy of Marriage," 1873, p. 70.

[3] " Principles of Biology," ii., p. 502.

development has ceased. If mental growth be unduly forced before structural completion, structural and sexual genesis are retarded or impaired. Professional training in women must, therefore, fall within the child-bearing period. In the case of men of great mental activity there is marked impairment of fertility.[1] The cost of reproduction to males is greatly less than to females, and it therefore follows clearly that the prolonged and intensified mental growth, the result of professional training, is to be deducted in full from the sum of the forces necessary to reproduction. M. Quetelet cannot doubt the influence of professional life upon fertility.[2] Mr. Herbert Spencer says, "that absolute or relative infertility is generally produced in women by mental labor carried to excess, is more clearly shown. . . . This diminution of reproductive power is not shown only by the greater frequency of absolute sterility, nor is it shown only in the earlier cessation of child-bearing, but it is also shown in the very frequent inability of such women to suckle their infants. In its full sense, the reproductive power means the power to bear a well-developed infant, and to supply that infant with the natural food for the natural period." [3]

Even were it not that absolute and relative infertility are against the woman undergoing severe mental discipline having children to inherit her improved cerebral evolution, and in favor of the average or inferior woman, still the very condition of this mental discipline, if the woman is preparing for the professions or skilled labor, involves a postponement of marriage to a period when, in the mass of wives, fecundity has received a permanent check. The average individual wife shows a degree of fecundity which, at the age of twenty-five, diminishes,[4] and this is the period at which the professional woman is prepared to enter upon her business career. The opinion of Mr. Sadler, that delayed marriages developed a degree of fertility in women which compensated for the loss of fecundity consequent upon the delay, is completely overthrown by the tables of Dr. Duncan.[5] If women are to enter the learned professions and skilled labors, they must be devoting themselves to training at a period of their lives when the mass of women are wives—mothers. I think that it must be conceded as a fact that, to contract matrimony during this period of mental and bodily training, would totally defeat the selected life-work of the woman. The desire to become the co-worker with man upon the highest level of man's work belongs only to superior women; if, in addition to this innate superiority, we add that acquired from increased cerebral development, the law of heredity would tend to continually en-

[1] "Principles of Biology," ii., p. 487.

[2] A Treatise on "Man and the Development of his Faculties." Translation. Edinburgh, 1842, p. 21.

[3] *Loc. cit.*, p. 486.

[4] Dr. Matthews Duncan, "Fecundity, Fertility, Sterility, and Allied Topics," Edinburgh, p. 43.

[5] Sadler, "The Law of Population," ii., p. 279.

large the number of women fitted by inherited traits to occupy this advanced field. But we have shown that the laws of sexual selection and of population are entirely opposed to the increase of women thus favored, and in favor of the average woman by a large per centum.

I am inclined to regard all forces which have hitherto acted, and yet continue to act, upon the great mass of humanity in the creation of sentiments common to the majority upon a given subject, as acting with the force of a law. I conceive, therefore, that there is yet another law which explains, and tends to perpetuate, the present relation of women to the other sex and to society. This is the law of public opinion. The exponents of public opinion upon this subject are the women themselves. I do not think any one will controvert me when I assert that a vast majority of women are opposed to their own sex entering the professions. One would naturally suppose that, in the matter of religion, a woman's opinion is as good as a man's; that, with equal learning and experience, a woman is as competent to discharge pastoral duties as a man (I am assuming the physical equality of the sexes); and yet you may count upon the fingers of one hand the number of pulpits filled successfully by women in this great country. In this country women are free to enter the medical profession; but, with about as many exceptions as that of women filling pulpits, they are gaining but a precarious and scanty support. Now, in both the professions named, women are retarded by the force of opinion of their own sex. In all social questions, women wield a great influence. In these matters they are the throne, and the power behind the throne. In Protestant congregations, if women were a unit in favor of women preaching, women would preach in a fair proportion of church organizations. If a woman made a free choice of a physician of her own sex, there is scarce a household in which she would be denied her choice. Women seem to lack confidence in their own sex in this position. In the desperate diseases peculiar to women, the sorely afflicted ones seek the medical man instead of the medical woman. The future has yet to produce the anomaly of the female ovariotomist. In the literature of medicine there has been but one Boivin, and but one La Chapelle. The reliance upon man in moments of bodily peril is easily explained; it is an inherited trait, strengthened by education.

I have said enough to explain philosophically the present relation of women to the other sex, and to society. It is this relation which has, in the past, regulated woman's admission into the professions and skilled labor. But we have now to accept the fact that women have entered the professions to contend with man in the struggle for existence. In this struggle, I presume, women expect no favors. In this new field of contest all they ought to ask for is a fair chance to win—the same chances man must take. But, in view of her present relation, and the radical physical differences between the sexes, have they a fair chance, and can they take the chances of man and reach his level in the professions? This is the question I shall endeavor honestly to solve.

Mentally, I believe woman to be the peer of man; that there is nothing about law, medicine, or theology, that woman cannot learn as well as he; that her mental difference is a sexual difference, just as her bodily differences are sexual. To the question of her mental fitness for this work, other than sexual, I shall give no attention. The physical difference between the sexes will form the first part of our study of woman's future relation to the professions, and brings us naturally to the discussion of the law of anatomical development as modified by sex. In the July number of THE POPULAR SCIENCE MONTHLY, in an article entitled the "Genesis of Woman," I endeavored to assign a proper value to the functional development of woman. In that paper, the anatomical development of woman was studied with reference to her functional genesis; but here it must be studied with reference to her fitness for competition with the opposite sex in the struggle for subsistence. Now, there are certain skilled labors which belong to man by virtue of his superior strength. The anatomical peculiarities of woman do not need to be contrasted with man's in reference to this class of labor, and women in the lower walks of life have demonstrated their ability for severe bodily toil. But the intellectual work—to which I am mainly directing my attention—to which women are reaching, implies that the candidates possess the delicate structural development, the inherited result of civilizing forces. We can draw no inference, therefore, from that fact that women, less exposed to these forces, and more nearly approximating man in physical strength, fully equal him in the value of their labor. If we examine some of the lighter and more delicate forms of skilled labor, such as we would naturally conclude were peculiarly fitted for the delicate and nice touch of women, we find them in the hands of men almost exclusively. The question of mental fitness must be excluded, for mentally they are as competent as man is to acquire and practise these arts. I think it can be shown that anatomical unfitness, aside from her inclination, is the obstacle. In the manufacture of instruments involving great delicacy, and, until the introduction of machinery, in the manufacture of watches, as a class women were excluded. While not involving any great muscular outlay, these samples of skilled labor demand great delicacy of educated touch. While we must make great allowances, as an anatomical factor, for the advantage to men so employed of the inheritance of mechanical taste and skill from fathers, oftentimes so employed for generations, yet it is a common error to suppose that employments which involve delicacy of manipulation do not require strength, as great in degree as, but differing in kind from, that demanded by more hardy labor. Educated, coördinate muscular movements depend more than any other upon strength and certainty of muscular contraction. In no particular, aside from sexual differences, is the male skeleton so greatly different from the female as in the irregularities and asperities of the bones for the attachment of the muscles. While in man they form a marked feature of his bony structure, in well-formed females they present but a comparatively scanty development. It is true that both muscles and osseous irregularities, for their origin and insertion, may be developed by training, yet woman, as at present related to the other sex, has not only to acquire his strength, by a course of extra training, but she must equal him in skill, if she is to prove a successful competitor for his place. These comparisons between the physical strength of the sexes would be altogether unfair, were it not for the fact that they are invited by the position women have elected for themselves, and are essential in giving an opinion of woman's chances of success.

The fact that those employments are chosen by women which permit a sitting position is significant in this relation. Woman is badly constructed for the purpose of standing eight or ten hours upon her feet. I do not intend to bring into evidence the peculiar position and nature of the organs contained within the pelvis, but to call attention to the peculiar structure of the knee, and the shallowness of the pelvis, and the delicate nature of the foot as part of a sustaining column. The knee-joint of woman is a sexual characteristic. Viewed in front and extended, the joint in but a slight degree interrupts the gradual taper of the thigh into the leg. Viewed in a semi-flexed position, the joint forms a smooth, ovate spheroid. The reason of this lies in the smallness of the patella in front, and the narrowness of the articular surfaces of the tibia and femur, and which in man form the lateral prominences, and thus is much more perfect as part of a sustaining column than that of woman. The muscles which keep the body fixed upon the thighs in the erect position labor under the disadvantage of shortness of purchase, owing to the short distance—compared to that of man—between the crest of the ilium and the great trochanter of the femur, thus giving to man a much longer purchase in the leverage existing between the trunk and extremities. Comparatively, the foot is less able to sustain weight than that of man, owing to its shortness and the more delicate structure of the tarsus and metatarsus. I do not think there can be any doubt that women have instinctively avoided some of the skilled labors on anatomical peculiarities.

The question is in order, To what extent will these anatomical disadvantages act as a bar to her future progress? The present skill of man is the sum of functional and organic evolutions attendant upon countless generations. Women, during this period, have also been passing through the same series of evolutions. But the sum attained by women, although equaling that reached by men in sexual value, differs totally in kind. Under the condition of the sexes we are studying, these lines of evolution must maintain a perfect parallelism in order to secure equality in the sexes. Physically and intellectually, the two sexes must move side by side to future evolution. At present, woman must unlearn part of her innate education, and acquire some of that of man; otherwise she cannot equal him in value of skilled labor. Woman must be content to grow up, to evolve, generation by generation, to a position from which she can compete with man in the fields of labor. I believe this condition of things not only can be realized, but in the course of generations will be reached. When we reflect that the present impaired value, in a labor point of view, of educated women is but the result of civilizing forces and the increment of inherited traits, and that women in lower or savage life fairly equal men in the value of their muscular development, we have every reason for this belief. The reader must bear in mind that I am treating of the sex as a unit. Individual exceptions, which always have occurred, and, however prolonged the existing relation of the sexes may be, probably will ever occur, do not apply as negative facts to my argument. The laws of sexual selection, of population, and of heredity, will oppose the advance of women, other than in this exceptional way. But there exists in society a force which is tending to the parallel evolution of the sexes. This force lies in the large excess of females in the adult population of many countries. Stern necessity will force—if this condition of affairs continues in the future—a large percentage of this excess to compete with man in the professions and skilled labor. Many of these trained women will marry and have children, and thus form nuclei, divergent lines from which will extend into posterity, ever adding increment upon increment to the forces which tend to parallelism in the evolution of the sexes.

The purely sexual anatomical differences I shall say nothing about; but the functional resultants of these anatomical conditions, both mentally and physically, must be studied with reference to their effect upon woman's chances of success. If we examine carefully the mental action of women, we perceive in it an undercurrent of sex. As there are organs which characterize sex, so also is there a sexual cerebration. We know from experience that this unconscious dominance of sex in cerebration in no way interferes with high culture, and the exercise of the best qualities of mind. It is a normal condition of mental action in women, but its existence implies conditions which may at any moment render mental action abnormal. Take the emotions, for instance, the undue exercise of which are so liable to assume morbid proportions, as in hysteria. Here sex, when it asserts itself unduly, obtrudes inharmoniously into what otherwise would be healthy mental action. It is in this class of mental actions, termed the emotions, that the mind of woman forms part of the sexual cycle. Some of these actions are so elementary that they are called instincts. The maternal affection, and also love, partakes of this instinctive character. The exercise of the sympathies is more general and active in women than in men. This is one of the features which give such beauty to the character of women, and is not the result of education. Mungo Park tells us that, when sick and thirsting, and maltreated by the natives of Africa, the women of the savage tribe visited him and supplied his wants. I will give one instance, which is a type of character, and shows how sympathy and natural feeling may interfere with professional advancement.

The wife of a practising physician, being of a scientific tendency of mind, acquired a theoretical knowledge of her husband's profession. The husband died, and left the widow poor and with several children, some of them so young as to demand much of her time and thought. She continued the study of medicine with the design of making it the means of support for herself and children. To this end she attended lectures at a woman's medical college. Before she obtained her diploma, an old, superannuated Presbyterian clergyman excited her sympathy by his forlornness. She gave him a home in a very womanly way—she made him her husband. Here was a double burden—an old man, and little children. This physician, although laden with her great, womanly heart, was prosperous in a small way. She secured the position of house-physician in the hospital connected with the college, with a small salary, and with sufficient time to attend to private patients. Her pecuniary prospects were better than those of young physicians of the other sex. The husband soon died. At this point in the history occurred an incident which seems to me to be phenomenal, and yet is typical. A second old clergyman, equally forlorn and wretched as the first, accepted the charity of this woman by becoming her husband. Her practice slowly increased; her children were well clad and well educated. A daughter married, and moved, with her husband, to a distant city. A son studied medicine, and the last husband died. The next act in this singular history reveals an intensity of maternal feeling entirely opposed to a business success in a difficult profession. Gifted with a fine mind, as thoroughly educated in her profession as the majority of medical men, with good health, and having reached that time of life when she was functionally at rest, and with every encouragement to remain at her post, yet she made a better mother than doctor. She resigned her position in the hospital; abandoned her private practice; and moved to the city in which her daughter resided, in order to be near her child and grandchildren—and there, in a strange community, recommenced the difficult occupation of a female physician. This history is truly a physiological study, and reveals the intensity of feeling which may exist in all women upon subjects which lie near the heart.

The common standard of professional success is a pecuniary one. Public opinion will apply this standard to women as rigidly as it does to men. It is a common experience to meet men of the highest mental training in their professions, yet who fail completely in a business sense, owing to idiosyncrasies of mind. In this way the sympathies and affections to which women are prone will retard them in their pursuit of a profession as a business investment. In the medical profession, to which women have a special leaning, the constant witnessing of human suffering and misery will call into play emotions which will interfere with the calm and deliberate study of each case, which its rational treatment will demand. The same objection applies to men; the medical man is rarely to be trusted to treat a difficult case in his wife, or child, or himself.

There is one fact in woman's functional life which is of vast importance to the subject of this paper, and which I refer to with great reluctance. This fact is ovulation. The mental reaction of this function is oftentimes of such a character as, for the time, to totally incapacitate for professional or other mental work. As this paper is written solely with the view of arriving at the truth in a matter of great practical importance, I must let this serve as my apology for referring plainly to this subject; and this importance requires that I let others, who are acknowledged authorities in gynæcology, speak for me.

Dr. Robert Barnes, of London, the author of the latest work upon gynæcology, uses the following unequivocal language: "The mind is always more or less disturbed. Perception, or at least the faculty of rightly interpreting perceptions, is disordered. Excitement to the point of passing delirium is not uncommon. Irritability of temper, disposition to distort the most ordinary and best-meaning acts or words of surrounding persons, afflict the patient, who is conscious of her unreason, and perplex her friends, until they have learned to understand these recurring outbursts. . . . Not even the best-educated women are all free from these mental disorders. Indeed, the more preponderant the nervous element, the greater is the liability to the invasion. Women of coarser mould, who labor with their hands, especially in out-door occupations, are far less subject to these nervous complications. If they are less frequently observed, if they less frequently drive refined women to acts of flagrant extravagance, it is because education lends strength to the innate sense of decorum, and enables them to control their dangerous thoughts, or to conceal them until they have passed away."[1] Another of the accidents attendant upon ovulation is hysteria. Dr. Tilt defines it as a disease peculiar to women during the reproductive period of life, and is often known to return at each period of ovulation.[2] This function is constantly liable to accidents. Speaking of the mental effects of æmenorrhœa, a disease to which every woman is liable who follows an intellectually rather than a physically active life, Sir J. Y. Simpson says that she becomes "subject to fits of excitement which come on most frequently at a menstrual period, and which usually assume an hysterical form, but

[1] "A Clinical History of the Medical and Surgical Diseases of Women," p. 162.

[2] "Diseases of Menstruation and Ovarian Inflammation," p. 129.

are, at times, almost maniacal in character."[1] I shall make but one other quotation, and I am glad to say that it bears directly and practically upon this matter. Dr. H. R. Storer, of Boston, is reported to have spoken as follows in a debate at the Gynæcological Society of Boston, May, 1870: "In the present excited state of public opinion, it were foolish, and at the same time unkind, to object to female physicians upon any untenable grounds; and he frankly stated that the arguments that physicians had usually employed, when discussing this subject, were, almost without exception, untenable. Some of the women who were desirous of practising physic and surgery were just as well educated for the work, had just as much inclination for it, and were as unflinching in the presence of suffering, or at the sight of blood, as were many male practitioners. They had a right to demand an acknowledgment that, in these respects, they were as competent to practise as are a large proportion of ourselves. There is, however, one point, and it is upon this that the whole question must turn, that has till now almost wholly been lost sight of: and this is the fact that, like the rest of their sex, lady doctors, until they are practically old women, regularly menstruate, and are therefore subject to those alternations of mental condition, observable in every woman under these circumstances, which so universally affect, temporarily, their faculties of reason and judgment. That these faculties are thus affected at the times referred to is universally acknowledged."[2]

Many other authors may be cited to the same effect; but these are sufficient to render evident the possibilities of danger, if not of disaster, to women subject to the ceaseless calls of professional life.

Among popular writers upon this subject, the matter of wifehood or motherhood has been treated as if, were woman willing to sacrifice some of her traditional feeling, and voluntary likings for the other sex, she might cast off the fetters of these honorable conditions, and move on untrammeled to the study and practice of a profession. We have been studying woman, in her relation to the subject of this paper, as a sexual being; and, if we continue the study in the same direction, we must arrive at the conclusion that marriage is not an optional matter with her. On the contrary, it is a prime necessity to her normal, physical, and intellectual life. There is an undercurrent of impulse impelling every healthy woman to marry. That this is a law of her sexual being we know by the positive evidence of medical men and others. We also know that the married woman exerts a more marked influence upon men, and society in general, than the celibate. There is also, among married women, a more perfect equilibrium between the intellectual, physical, and sexual forces; and yet, necessary as marriage is for woman, in the present relation of the sexes, it must in every way impair her prospects of success in professional work.

[1] "Diseases of Women," p. 617.

[2] "The Journal of the Gynæcological Society of Boston," vol. ii., p. 267.

The effect of celibacy upon women has often elicited the remarks of gynæcologists. Dr. Tilt says of marriage: "It is easier to prove the benefits of marriage than to measure accurately the evils of celibacy, which I believe to be a fruitful source of uterine disease. The sexual instinct is a healthy impulse, claiming satisfaction as a natural right."[1] Again: "An enlarged field of observation convinces me that the profession has not in any wise exaggerated the influence of marriage on women, and that its dangers are infinitesimal as compared with those of celibacy."[2] Nearly every treatise upon gynæcology may be quoted to establish the same fact. It is upon the mind of woman that the defeated sexuality acts reflexly in a morbid manner. Dr. Maudsley, who has had abundant opportunities for observation, says: "The sexual passion is one of the strongest in Nature, and as soon as it comes into activity it declares its influence on every pulse of organic life, revolutionizing the entire nature, conscious and unconscious; when, therefore, the means of its gratification entirely fail, and when there is no vicarious outlet for its energy, the whole system feels the effects, and exhibits them in restlessness and irritability, in a morbid self-feeling taking a variety of forms."[3] While it is true that the engrossing cares of professional life, or of a skilled labor, will serve as a partial "vicarious outlet for its energy," in contrast to an idle life, yet this will in no manner act as a substitute for the natural expression of this physiological want. Its constant suppression will tinge the thought and manner of the woman. This is not an unreasonable statement, when we reflect that bodily derangements, not at all serious, will often account for changes in the mind and manner, as well as for the entire mental habit of men otherwise strong. If we contrast her with man in this respect, the chances are infinitely against woman in professional life. The penalty of sex is an episode in man's life. The tribute to his sexuality once paid, he is practically unsexed, and the trained intellectual man moves among women and men with scarcely more than a consciousness of his reproductive faculty. But sex in woman is a living presence. From the age of fifteen to that of forty-five, her life is crowded with startling physiological acts. Ovulation, impregnation, conception, gestation, parturition, lactation, and the menopause, contend with each other for supremacy—each act a mystery; each attended with its peculiar peril; and most of them evoking in its behalf the highest efforts of which her physical organization is capable. It will demand genius indeed to enable woman to rival man in the field of labor, and, at the same time, contend with the *inexorable law of reproduction.*

Having shown that women are not free agents in the matter of marriage, but do so in obedience to a primal law of their sexual life, we will next consider what are the chances for the married women in

[1] "Uterine Therapeutics," p. 224. [2] *Loc. cit.*, p. 127.

[3] "The Physiology and Pathology of the Mind," p. 203.

professional life. In a physiological study such as this, we will not concern ourselves with the social obstacles a married woman must encounter. We have a right to consider every woman who has a husband as either a mother, or liable to become one. Any attempt on the part of a wife to avoid children in order to free herself of that obstacle to professional life would be attended with consequences to her mental and physical health which would seriously impair her usefulness.[1] The end and aim of woman's sexual life is perfected by maternity. It broadens and elevates her intellectually and physically. The influence over society reached by wives-mothers is a natural outcome of the stimulus of maternity. The maternal instinct, which lies dormant in the nature of every woman, awakens her mental being into increased activity the moment it is called into life. I think that it is for this reason that frail women, with no knowledge of life, when widowed, often succeed in keeping their families together and providing for them. With the woman who is constantly liable to the demands of a profession, or skilled labor, the maternal affection, anxiety, or care, may intrude at moments when her occupation will demand her highest mental efforts. The manual labor of rearing children the professional woman may delegate to others, but the ceaseless love, care, and forethought, so beautiful in a mother's love, the true woman must assume herself. Physically, children are necessary to the married woman. The sterile wife is constantly exposed to diseases that the fecund wife is comparatively exempt from. The sterile wife is not a normal woman, and sooner or later this physical abnormality finds expression in intellectual peculiarities. Not upon the mind alone, but upon the body as well, does motherhood have a maturing influence. Gestation is nearly the completion of the sexual function. The process involves increase in the size of the heart, and in the volume and strength of nearly all the muscles of the body.[2] It is evident from this that gestation is not only a functional completion, but it is necessary to structural maturity, and to me it seems a natural corollary that it has an equal effect in increasing mental vigor. Having shown that marriage is in obedience to a physiological law, and that maternity is necessary to insure mental and bodily health in the mass of women, it is proper for us to ascertain if the last of these conditions—gestation—is not of itself, physically and mentally, an obstacle to professional life in women. The physical incapacity is too evident to need any comment.

Mentally, the changes undergone are most singular and multiform, and operate upon the cultivated and ignorant alike. Dr. Montgomery, speaking of the nervous irritability of pregnancy, says: "It displays itself under a great variety of forms and circumstances, render-

[1] Bourgeois, "The Passions in their Relation to Health and Disease," p. 162, *et seq.*

[2] Dr. Alfred Wiltshire, "On the Influence of Childbearing on the Muscular Development of Women." Transactions of the Edinburgh Obstetrical Society, vol. ii., p. 237.

ing the female much more excitable and more easily affected by external agencies; especially those which suddenly produce strong mental or moral emotions. Hence the importance of preventing, as far as possible, pregnant women from being exposed to causes likely to distress, or otherwise strongly impress their minds."[1] These objective mental conditions described by the author must not be regarded as exceptional; on the contrary, they are classed among the usual symptoms of that condition. Still more marked mental disturbances may occur and are not rare, as in the following quotation from Dr. Storer: "Strange appetites, or longings, as they are called, and antipathies, are well known as frequent attendants on pregnancy in many persons."[2] And further: "The evidence that I have now presented proves that the state of pregnancy is one subject to grave mental and physical derangements, giving rise to serious anxieties, and requiring judicious treatment."[3] These mental effects are of minor importance in the relation we are studying, when we consider the fact that absolute insanity may be an accompaniment of either gestation, or follow parturition. Dr. Maudsley refers to this as explaining the excess of female insane over that of the other sex.[4]

Dr. Forbes Winslow draws a startling picture of this catastrophe: "When, after numerous struggles to repress them, the propensities excited into such fearful and almost supernatural activity by ovarian irritation burst forth beyond all control, and the pet of the family is seen to be the opposite, morally, in every respect to what she had been—irreligious, selfish, slanderous, false, malicious, devoid of affection, thievish in a thousand petty ways, bold, maybe erotic, self-willed and quarrelsome; and if the case be not rightly understood, great and often irreparable mischief is done to correct what seems to be vice, but is really insanity."[5]

We have but one other sexual accident to consider which may act as a bar to woman's progress in the professions. These accidents are incident to the climacteric period of life. This period includes the years between forty and fifty, and, judging from men, a professional woman ought then to be most actively engaged in her occupation. It is during the functional changes then taking place that women are exposed again to the dangers which attend the advent of puberty. It is the second and last crisis in the functional life of woman. We will let the mere bodily diseases of this period pass unnoticed, and refer to those of cerebral origin, as mind forms the working organ of the professional woman. Dr. Bedford regards the varieties of nervous irritation peculiar to this period as "beyond calculation."[6] In fact, it is upon

[1] "Signs and Symptoms of Pregnancy," p. 17.

[2] "The Causation, Course, and Treatment of Reflex Insanity in Women," p. 139.

[3] Ibid., p. 148.

[4] *Op. cit.*, p. 207.

[5] *Journal of Psychological Medicine*, January, 1851, p. 43.

[6] "Clinical Lectures on Diseases of Women and Children," p. 374.

the nervous system principally that the cessation of ovarian function acts reflexly in an abnormal manner. Thus, 500 women divided among them 1,261 forms of cerebral disease, confirming the general belief in the frequency of cerebral diseases at the change of life.[1] The liability to insanity at this period is greater in women than in men. Leaving out of consideration such an extreme result as insanity, yet the lighter shades of nervous derangement which would entirely unfit a woman for healthy mental work are so multiform, and to which men are in no way exposed, that it is evident that at this period woman would encounter some of the most stubborn barriers to her success in professional life. The professions, in giving undue employment to the mind, would greatly predispose a woman so employed to nervous disease at the change of life. Her very employment, to which many are working their way so bravely, is almost sure to entail suffering and danger at a period when educated and refined women, more than any others, require mental and bodily repose, and which the nature of their employment forbids. With this brief notice of this important crisis in the life of woman I shall close this part of the subject, and simply offer, in conclusion, a summary in the form of a

RECAPITULATION.

The moral subjection of woman to man is a sexual peculiarity.

This has been perpetuated and intensified in the human family by the law of heredity.

That the tendency of civilization and education to antagonize this subjection of the sex is neutralized by the law of sexual selection.

That the chances of intellectually active women leaving issue to inherit their improved mental character are greatly in favor of the average woman in obedience to the law of population.

That women are retarded in their advancement to professional work by public opinion.

That women have unconsciously avoided some of the skilled labors by reason of anatomical unfitness, and which will be operative in the future.

That sexual cerebration is liable to assume undue prominence in the cultivated and ignorant alike, and thus unfit her for professional mental work.

That women marry in obedience to a sexual law, and not from choice; and that marriage, in the present relation of the sexes, is an obstacle to professional success.

That if women remain single, in order to enhance their professional success, celibacy entails many physical and mental evils, which will impair their value in professional life.

That ovulation may, in many cases, be the cause of mental excitement, or require strong efforts of repression, which would unfit her, for the time, for professional work.

[1] Dr. Tilt, "The Change of Life in Health and Disease," pp. 164, 185.

That children are necessary to the mental and physical health of married women, but that maternity is unfavorable to success in skilled labor or the professions.

That the functions of gestation and parturition are very liable to be attended with mental disturbances which would totally defeat a professional career.

That the change of life is a critical period, prone to be attended with mental and bodily infirmities, unfitting a woman for professional work.

With such possibilities before her, and such necessities urging her, what chance has woman of successfully competing with men of mediocrity in professional life, or in skilled labor? It must be the intent of every woman who essays a professional life to do man's work as well as man can do it, and to secure man's reward for such well-doing. But, I cannot avoid the conclusion that, in the present relation of the sexes, such a standard is impossible of attainment. Whether the conditions which have created and continued the present relation of the sexes will operate as potently in the future as in the past, is a difficult question to answer. I have already said that, in my opinion, there now exist in society forces which will tend to modify the dependence of women. Prominent among these is the persistence with which women are working their way to new relations, which, if continued, will certainly bear fruit, and evoke in its behalf the law of heredity, which is now opposed to them. If we look upon society in a scientific spirit, we must recognize it as a field in which antagonizing forces are contending. This effort of woman to invade all the higher forms of labor is a force battling with the established order of sexual relation. The inertia which it encounters is the universal attendant of established facts in society. If this effort of woman is continued into coming generations, I have no doubt but her relations to society and labor will be in many respects modified. But I believe a long series of generations must pass before women can equal the labor value of men in the professions.

REASON AGAINST ROUTINE IN THE STUDY OF LANGUAGE.

FROM THE FRENCH OF CLAUDE MARCEL.

Part II.

I. GRAMMAR.—Can the exercises of the university and of our lyceums give to pupils the advantages they ought to expect in linguistic study? No, a hundred times no! There is little in these exercises that addresses the judgment, or that will be useful in the course of life. The pupils never read authors, they translate them before they comprehend them; or else translate them in fragments—two infallible means of never knowing them.

The first book put into their hands is a grammar, the most abstract, the most fatiguing, the most unintelligible book that can be imagined, while, at the same time, it is the most useless at the beginning of the study, when the pupil has not yet gained a knowledge of the facts on which it rests. Contrary to reason, the grammar treats of words that occupy the attention before the ideas they represent. It is but a collection of rules and definitions, more or less obscure, incomprehensible, and inapplicable, as preparatory study.

If, as reason teaches, the art of reading is the first object of this study, grammar is not the least help in securing this end: it does not give the meaning of phrases and words, the only difficulty in beginning to read a foreign language. The thought of the author, in other words, the translation that interprets it, not the grammatical condition of the words, should be the first object of consideration with the beginner. He might know the grammar from beginning to end without understanding a word of the language. It certainly is not the art of reading, and cannot be the introduction to the study of language. The method that gives priority to the arts of speaking and writing has recourse to grammar at first; for, in default of example, rules are the only guides of study. But in reading, as in listening, the phrase presents itself, as a whole, to the mind; rules which coördinate the composition have no force until its parts are understood. It is, in fact, by language that we comprehend the grammar, not by grammar that we comprehend language.

Admitting that grammar teaches to speak and write correctly, that is not teaching to *speak* and *write*, but only to do them correctly; in other words, to avoid or correct errors that might glide into expression and thought. It is, therefore, necessary to begin by speaking or by writing, to get any advantage from the rules of grammar.

In beginning with grammar, children do not see its utility, and are disgusted. They are neither interested nor profited, because they do not give it their attention. On the contrary, what interest grammar awakens, when, in place of presenting it dead, so to say, in an abstract manner, it is made to arise from the phraseology, rousing the curiosity, leading to the generalization of facts through observation and reflection, and so opening a vast field to the intellect!

Of all the means that tradition and routine have established in teaching language, grammar is, perhaps, the most prejudicial in retarding practical knowledge. By a deplorable violation of the laws of Nature, substituting synthesis for analysis, putting precept before example, theory before practice, grammar is made the base of language. The minds of children are loaded with principles and theories, roots of words and their etymologies, as if they were all to be philologists and teachers of languages.

Grammar indicates, only in a limited way, the received usage; there are many idiomatic expressions concerning which it is no help.

It does not explain the value of words, nor their proper use, and adds little to our vocabulary, though an abundance of words is indispensable to correct speaking and writing. It teaches neither pronunciation nor accent, nor the orthography of the variable parts of words, nor their diverse meanings, nor the difference of signification between words improperly called synonyms, nor the propriety of figurative language, nor any of those delicacies of expression which constitute the genius of a language, and characterize a clear, elegant, and correct style. So grammarians, who devote their lives to the rules of language, are scarcely famous for their style. I do not know of one who has ever distinguished himself as an orator or writer. On the contrary, the greatest writers, such as Corneille, Pascal, Molière, La Fontaine, and others, owe nothing to grammar; it did not exist in their time. The same is true of Homer, Thucydides, Virgil, Cicero, Dante, Petrarch, Milton, and Shakespeare. Grammar, then, is not the art of speaking and writing correctly, and still less is it the art of reading, by which we ought to commence the study of language. "I should be glad," said Locke, "if I could be shown the language that could be learned by the rules of grammar." "A century of theory," said Lemare, "will not advance us a step in the knowledge of language." "It is the grossest mistake," said Condillac, "to commence with rules."

M. Jules Simon, in suppressing the mnemonic lessons of grammar, has rendered a true service to linguistic teaching. Rules, no matter what, or how many, confided to the memory, will never instruct a man, nor will they give habits of patient observation. A man might learn by heart all the laws that govern the sciences, and hold them as certainties, without at all developing his intelligence. If we could introduce into a man's head, without effort on his part, a knowledge of all the facts and results of scientific research, he would be in reality less capable than he who had learned, by a rational method, to work out a sum in the rule of three.

As a corollary of the grammar, children make grammatical analyses which draw their attention to the classification and function of words, but do not in any way enable them to understand an author, or express their own ideas, or exercise the judgment. These analyses teach grammar, not language. The man without the least ability for making them understands what he says, or what is said to him, as well as the most profound grammarian.

II. Of Themes.—The theme, auxiliary to the grammar, and the favorite exercise of the university, is no better than the grammar to teach reading. The understanding of a written text does not imply the power to write. Reason requires that the learner read before writing, and so secure the means of knowing good usage and imitating the style of great writers. The particular figurative words of a language that have no French equivalents, and the idioms of frequent use in conversation, are quite outside of themes which simply exemplify the rules of grammar. They give some exceptions, but few in comparison to the whole number. The verb *faire*, to make, for example, is translated into English in more than a thousand different ways, in as many idiomatic forms of expression. Frequent intercourse with foreigners, or else assiduous reading of good writers, can alone make these expressions familiar. Besides, it is contrary to reason to oblige children to compose in a language they will never, perhaps, have occasion to write, when comparatively so little effort is made to acquire the talent in their own language where it is so useful in every moment of life.

Sources of error and *ennui* as are these sterile tasks, they seem calculated to mislead, rather than to form, the judgment. Like most routine processes, they appear to have been invented to give masters business in correcting errors that would have been impossible by processes conformed to reason.

Themes are condemned by all writers upon linguistic study. Rollin, timid as he was in reforms of teaching, said: "To compose well in Latin, one must know the turn, the phrases, the rules of that language, and have accumulated a considerable number of words, the force of which he feels, and of which he can make a proper application. All this can be done only in translating authors who are living dictionaries and speaking grammars; by which he learns the force and true use of words, of phrases, and of rules of syntax. To do this, themes must be absolutely discarded, as they only torment children by painful and useless labor, and give them disgust for a study which brings them only reprimands and punishments." The intimate relation between thought and style, in composition, exercises the highest reason only when the language is the direct and spontaneous expression of ideas, as it is in the mother-tongue; but, in writing a theme, the student is not occupied by the thought; his attention is only directed to the words—their orthography, their concordance, and their arrangement, conformably to the rules he has under his eyes, or that he has previously studied. However, the university makes the knowledge of a language consist in the art of writing it, the least useful part, the least interesting, and the least calculated to exercise the intelligence under the conditions in which it is done. The translation of a native author into a foreign language, which is frequently imposed upon beginners, surpasses in absurdity the method of syntactic themes. It demands of the inventive faculties that which depends solely on imitation. How, without having heard a language, or read it much, without knowing the true value of its words, without knowing what approved usage allows or condemns, and in complete ignorance of its idiomatic forms of expression—how, I say, can a pupil form correct phrases? Knowing neither the different acceptation of words, nor the shades of meaning which distinguish synonymous words, nor the constructions peculiar to the genius of the language, the student never has occasion to compare, to judge knowingly; he chooses neither the proper word nor the most suitable form, and cannot aim at clearness, force, or elegance of style. The longer he perseveres in this thankless work, the less chance has he of ever writing the foreign language in its idiomatic purity. Latin compositions of this kind have been kept up to the present time, because they were not controlled by critics of the time of Augustus.

Translation into the national language presents numerous difficulties to those who best understand it. Lamartine called a translation the most difficult of all books to make; and we set young children at this work in an idiom which is nearly unknown to them. As well force them to walk with the head in a sack. It is a real tyranny.

The hours passed out of school by the unhappy victims of routine, in writing their themes and versions, leave little leisure for reading; while, on the other hand, the correction of tasks consumes time in class which would be better employed in studying the great writers of Athens and Rome. With an excess of zeal, the master often corrects the tasks of his pupils at home, consuming time which might better be given to his own improvement.

In the intervals of the lessons, the pupils of the lyceums read what the professor can hear them translate in class—an insufficient amount of practice for acquiring the art of reading in the school-period. They translate scarcely thirty lines a day in class, two or three times a week, making a small volume in a year, when the complete acquisition of this art would require the reading of more than fifty volumes. The remedy for this evil would be an initiative, on the part of the pupils, which would lead them to read outside of the lessons of the master; but, unhappily, this initiative is not encouraged. Grammar, themes, memorized lessons, and translations with the dictionary, are too discouraging, and do not dispose to voluntary effort.

One of the worst evils of the university system is, that not a step can be taken without a master. In place of exercising the pupils in the imitation of good models, which would in part dispense with his aid, they are pushed in a false direction, where they seek their way painfully, and cannot advance without help; while the professor discourages them by corrections which are renewed without ceasing.

Self-guidance is the first condition of a reasonable, improvable being. Children should learn at school how to study alone—to discover for themselves what they wish to know. In giving them no initiation, in denying them their free-will, we prepare them to resign themselves to the passive part imposed upon the nation by governments that take the initiative in all measures of social interest. We thus form subjects for a tyrant, not citizens of a republic.

III. Oral Translation.—In the beginning, translation is only a means, yet, strange to say, it is the means only that is regarded in the lyceum, without ever thinking of the end to which it conduces. And, still worse, it is translation word by word. This occupation of the mind with words is bad in many respects: it does not appeal to the judgment of the pupil, who, in ignorance of the subject, translates them at a venture; it does not permit him directly to associate the idea with the word of a foreign language; it hinders the understanding of the text; for, the words sought by the aid of the dictionary and in the order of the foreign text being found by him in a disorder to which he is not accustomed, they do not present a clear and definite meaning. On the other hand, no two languages ever correspond word for word. In each there are a great number of phrases with no equivalents in the other, and, consequently, ideas that cannot be rendered into it. Hence it is impossible always to translate faithfully.

Translation with a dictionary, which substitutes the fingers for the intelligence, and, scorning reason, proceeds from the sign to the idea, rests on the false principle of the identity of signification in the corresponding words of two languages. Moreover, by its slowness, by the multiplicity of its interpretations, and the tediousness inseparable from its use, it repels beginners and retards their progress. Besides, to a child little versed in his own language, words translated one by one present but a vague meaning, or none at all. The text, which alone can determine it, he does not understand. Explain the unknown by the unknown; such is the vicious circle in which the dictionary places him.

It is, in part, to this illogical, repelling process that we must, in the majority of cases, attribute the failure of linguistic study. Those who say that the use of the dictionary impresses the words on the memory mistake strangely. They forget that this way of finding the meaning is not the fruit of reflection, and, consequently, leaves no traces in the mind. It is a simple acceptance of another's word, with the further uncertainty arising from the diverse interpretations of each word. A few years after leaving the lyceum, what do we know of the Latin and Greek learned with the dictionary? With this pretended auxiliary, observation and judgment are entirely inactive. The student does not choose between different interpretations, for, not knowing the thought of the author, he cannot know what would render it most faithfully.

Indirect reading or oral translation is insufficient, at all stages of advancement, to give a neat and precise idea of the thought of the writer, or appreciation of the literary value of a work. Still less, by its means, could the scholar study science with profit. The search for expressions corresponding to those of the original prevents the mind from following the logical connection of ideas, and from abandoning itself to the meditation which such serious subjects require. It is only in direct reading that the attention is left free from foreign considerations, and can enter fully into the thought of the author.

All the qualities and graces of style, which are the principal merit of works of imagination, are lost when the attention is absorbed in the choice of words which will best render the thought of the author. Poetry, especially, cannot be read by the translator. All its beauties and merits disappear in passing into the prose of another language. Besides, the study of poetry is of no use in acquiring the materials of discourse for the exchange of thought with foreigners, or in following the progress of civilization among other people. The student should enter upon such reading only at an advanced period of study, when he can mark the rhythm and the cadence. Milton, for instance, who is on the programmes of the university, is not understood by the majority of the English, and yet our young people, who have not read more than four or five volumes of English prose, are expected to understand it in the translation!

IV. Pronunciation.—The premature exercises in pronunciation, made necessary by the priority given to the art of speaking, are contrary to reason in proceeding from letters to sounds; since it is necessary to know the pronunciation in order to establish the value of the signs which represent it. It is this inversion of logical order which has given birth to reading aloud, to all the systems of written pronunciation, to all those dissertations on the letters of the alphabet in the beginning of most grammars.

The real use of reading aloud is to test the progress made in pronunciation; and, when once it is acquired, to keep it in memory by practice. But, at the beginning of study, it is a process doubly irrational: it implies that the sign leads to the thing signified previously unknown; and it presents characters to the eye instead of sounds to the ear, thus moulding the pronunciation upon the orthography, which often represents it only imperfectly; especially in the case of the English language. The attention of the pupil is occupied with the pronunciation of words without regard to their meaning, to which pronunciation is subordinate. This proceeding has become very general only because, demanding no knowledge on the part of the master, it is suited to the capacity of those who wish to teach.

Reason requires that we adapt means to ends, but reading aloud is precisely the reverse of that which occurs in conversation. In reading, we pass from the word to the idea; the orthography suggests the sound. In speaking, on the contrary, we pass from the idea to the word; the sound suggests the orthography. Reading aloud can be only a source of error to a beginner. The corrections required will never form good habits, for these are the result of the repetition of correct impressions, such as are produced by the words of the master when reading to his pupils. To speak and pronounce a foreign language correctly, we must hear it spoken habitually. The alphabetic combinations by which we represent the foreign pronunciation are equally irrational. They can only bring to the mind of the student the sounds of his own language. It is by hearing sounds, and not by seeing letters, that pronunciation is made familiar, and yet exercises for the eye have the first place in our methods. It is impossible to represent unknown sounds to the eye by any combination of letters whatever, still less the diverse shades of intonation which characterize the speech of a people.

It is an error to believe, as is commonly done, that we cannot read a foreign text, in the sense we attach to this word, without pronouncing it, at least mentally. In the mother-tongue, the meaning of written words is conveyed to the mind only by the sounds that they represent, the ideas being *a priori* associated with the sounds. But the words of a foreign language do not recall to the student, any more than to a deaf-mute in his own language, any sound associated with the sense. There is, then, no necessity, as there is no possibility, of pronouncing it. It is, in fact, with the written signs of a foreign language, as with all other signs—we may know their value without attaching to them a sound; the Chinese characters, for example, are understood detached from all pronunciation. The young child associates the sense with the sound of words, and has no need to think of their orthography; in the same way, the student of a foreign language should associate the sense with the orthography of words, not with their pronunciation. If, as the rational method prescribes, we always pronounce the French when following with the eye the foreign text, we protect ourselves from a false pronunciation; for it will be impossible to pronounce English at the same moment when the organs of speech are occupied in pronouncing French.

V. Lessons in Memory.—Of all the exercises which most favor ignorance in teachers who are not duly prepared, and which inspire most *ennui* in students, the worst are those mnemonic exercises in which the master acts a purely passive part, and the pupil an automatic one. It is said that by such means we develop the memory of children, but for this no special effort is needed, as the culture of memory, like that of attention, is secured by the activity of the other faculties. It is more particularly in exercising the judgment that we enrich the memory with useful things. The knowledge we gather in the first years of life we owe to observation and experience—the best of masters—and it is more profoundly engraved upon the memory than all the memorized lessons of college. The mother-tongue is acquired without learning any thing by heart.

Those who, in teaching their pupils to speak a foreign language, give them words to learn, to form into phrases, commit a triple error. In the first place, the child does not learn to talk by passing from words to phrases. In the second place, in order to speak, he learns to understand what is said to him. In the third place, no mother ever attempted such a proceeding: the instinct of imitation alone suffices the child in learning to speak.

The expression of thought is not aided by learning extracts from authors, because, for the most part, these extracts contain not a phrase or an idea that would aid in conversation. In this work, the attention is directed exclusively to words, and the memory is aided by their juxtaposition. By means of repetition they are revived in the mind in their order of succession, each word suggesting that which follows. The more we repeat the lesson in order to retain it, the more easy and rapid the recitation, the more the text escapes analysis and the will. Excellent as the exercise may be in pronunciation and oratory, it is inefficacious as a means of learning to speak. To learn a model by heart, no more teaches to speak, than tracing a drawing-model teaches to draw.

The monotonous repetition of a text is a mental operation diametrically opposite to that employed in the expression of thought. To speak is an act of judgment, to recite is an act of memory: the first is spontaneous, the second mechanical; by this we associate words with ideas, by that we associate words with each other; in the one we are masters of an ever-changing phraseology, in the other we are the slaves of an invariable text. In speaking, the mind is exclusively occupied with ideas; words present themselves as consequences. In reciting, on the contrary, it is words that absorb the attention, ideas following in their suite, and sometimes even are not present to the mind; children often fail to understand what they know by heart. Montaigne said, with reason, "To know by heart is not to know."

As to dialogues or exercises in conversation, whatever the number of them with which the student has charged his memory, he can say nothing beyond some trivialities which it has pleased the compiler to group together. His individuality disappears, and he is only the servile echo of phrases that have been imposed upon him. It is manifest that the art of speaking, of managing a language at will for all the needs of conversation, consists less in remembering a great number of ready-made phrases, than in the power of constructing at will, and instantly, those that meet the necessities of the moment. It will be more profitable, then, to follow the process of Nature, which consists in constructing phrases for one's self, on a given model, by analogy.

The time given to learning dialogues profits little; for, most commonly, they are forgotten long before there is occasion to use them. Phrases learned by heart are rapidly forgotten. Not only are these lessons worthless, but they require painful labor and considerable time; they are, for young people, an incessant cause of disgust and punishments, which can only inspire aversion for the study. They do not even serve usefully to cultivate the memory; for the power to retain these words in a given order is of no use except to actors in learning their parts.

We cannot by special processes obtain the general improvement of a faculty. The power or aptitude of a faculty never transcends the limits assigned to it by the special exercise to which we submit it.

All the faculties are subject to this law. Thus, persons in whom the ear, exercised in melody, distinguishes the most delicate tones in music, are not those who best seize the pronunciation of language. The eye exercised in colors does not better appreciate form and distance; and reciprocally.

Again, the development of the intellectual faculties is always conformed to the kind of exercise which produced it. Those who have learned much by heart, learn easily by heart; but they are not in consequence better able to recall facts, dates, localities, forms of objects, subjects of discourse, the details of a profession—nothing, in fact, which is useful for the exigencies of active life. It is to falsify Nature to ask from the memory of words that which can alone be given by the memory of things.

All the time spent by a child in learning its lessons by heart is lost, as far as concerns the exercise of judgment and the practice of language. In a class, the great majority of pupils remain idle while waiting their turn of examination. As to the master, what does he do? He does not instruct. Whatever he knows, his knowledge is a dead page for his pupils. He who, in his teaching, does not go beyond the contents of the book is unworthy to be a teacher.

It is with mnemonic lessons as with other useless drudgery imposed on the young, which, without profit, puts their intelligence to torture. All these preparatory exercises end in nothing practical. They only retard the acquisition of direct reading. If the employment of these diverse processes continues in our lyceums, they will give no better results than they have given in the past, with professors probably as clever, as zealous, as anxious to do well as their successors.

VI. Conclusion.—We would not object to the length of time spent in classical study, as we have hitherto had a right to do, if the pupils, giving not more than eighteen months or two years to acquire that which alone is useful in the ancient languages, the art of reading them, derive advantage from them during the remainder of their school-life, however long it may be, in cultivating their minds, and extending their knowledge of the national idiom. Unhappily, this is not the policy in public instruction. As regards the living languages, students leave the lyceum, for the most part, without having attained any of the objects of study. They are persuaded that they have nothing to learn, when they know by heart all the rules of grammar, have written all the themes they contain, and learned a volume of dialogues; when they commence to translate fluently, to read aloud good or bad, and to make correctly grammatical and logical analyses. However, nothing of all this is really the practice of language. Nothing of all this finds its application in the commerce of life. They know the language *by rule*, which means, in most cases, that they can neither read, nor understand, nor speak, nor write it.

It is particularly in the study of classics that routine is pernicious to the young. The university system, which involves an enormous expense of time and money, is no longer in harmony with our civilization. It disregards the diversity of talents, the specialty of individuals, and casts all minds in the same mould. It conforms neither to the laws of Nature nor the needs of modern society; it calls in play neither spontaneity, nor curiosity, nor imitation; it surcharges the memory to the prejudice of the judgment, and aims at verbal acquisition rather than mental culture.

It does not embrace any of the great classics. It reverses the order of reason in passing from words to phrases, from theory to practice, from the art of writing to the art of speaking. Finally, it sacrifices the great majority of students to a few privileged ones, and all are too much occupied in things of the past to the exclusion of that knowledge which the progress of civilization has made indispensable.

It is to be wished that the Minister of Public Instruction may, in the interest of our country and society at large, honor with his attention the preceding observations, and use his powerful influence in favor of the substitution of reason for sterile routine in our schools! To appeal to the past, as is done at the university to justify its proceedings, is to hold intelligence in tutelage, and to condemn France to immobility. The world, in growing old, adds to the experience of man. Enlightened as we are by what we have received from our fathers, we commence life in the most favorable conditions. We ought to know more than they, and be more able to distinguish truth from error. Let us go forward with our century. It is time to leave the rut of tradition.

Let the fathers of families unite in appealing to the minister not to permit our lyceums to perpetuate a system of teaching that favors the ignorance of the people as a means of government. But let him take in hand the great work of the regeneration of linguistic study. We must apply to mind, as to matter, new powers and new processes. France will awake to intellectual life, and rise to a level with the most enlightened nations, only when its university teaching is completely conformed to the laws of Nature and the demands of reason.

PARALLEL.

BY THE RATIONAL METHOD.	BY THE METHOD OF ROUTINE.
1. We follow step by step the indications of Nature.	1. We follow in nothing the precepts of Nature.
2. Curiosity and imitation are the source of progress.	2. We are not aided by these two powerful instincts.
3. We go straight to the object by example and practice.	3. We start from rules and preparatory studies.
4. Grammar becomes the consequence of language.	4. Language is made the consequence of grammar.
5. We understand the foreign text before we translate it.	5. We translate the foreign language before we understand it.
6. The art of writing is the last in the order of study.	6. The art of writing is the first in which the pupil is exercised.

7. Pronunciation is acquired without effort by the ear.	7. Pronunciation is acquired with difficulty by reading.
8. We understand foreigners as well as natives.	8. We cannot understand the foreign language when spoken.
9. Nothing is learned by heart.	9. Much time is spent in memorizing lessons.
10. All our processes tend to prevent mistakes.	10. All the processes tend to produce mistakes.
11. We have no need of a master for pronunciation.	11. We cannot learn pronunciation without the help of a master.
12. We are soon able to think in the foreign idiom.	12. We never come to think in the foreign idiom.

A SHORT STUDY OF BIRDS'-NESTS.

By CHARLES C. ABBOTT, M. D.

I.

HAVING had many opportunities of examining the nests of those birds habitually breeding throughout Central New Jersey, during the past fifteen years, and so, familiar with the construction and location of such nests, I have, since the publication of Mr. Wallace's essays on "Natural Selection," in 1870,[1] endeavored to determine if the theory there expressed was applicable to the birds that are common to the locality we have mentioned.

In so studying birds'-nests, I have carefully avoided prematurely arriving at any conclusions that might influence my judgment when subsequently examining a series of nests, and therefore I believe the notes made concerning the construction of each nest, and the inferences drawn, are exact in the former case, and justifiable in the latter.

At the very outset, I found a careful study of the courtship of birds essential to a proper appreciation of their subsequent habits, and learned, not at all to my surprise, that marriage among birds, as among mankind, is not universal, but that both bachelor and spinster birds of every (?) species constitute a fraction of the ornithic population of our woods and fields.

I reached the above conclusion in this way: Having carefully gone over a given extent of ground, and noted every nest, say of the cat-bird (*Galeoscoptes Carolinensis*), I have then endeavored to learn about or precisely the number of individuals of this species frequenting the same extent of territory. As birds, during the breeding-season, do not wander any very great distance from their nests on the one hand, nor from the locality whereat they halt on their arrival in early spring, on the other hand, it is not very difficult to reach a very

[1] Essays on "Natural Selection," by A. R. Wallace. Macmillan & Co., London and New York, 1870 (pp. 211–263 inclusive).

close estimate of the numbers of each species occupying a locality, any given season. Thus, during May and June, 1873, I found eleven nests of the cat-bird in a given area, and feel confident that I recognized twenty-seven individuals of this species. If this is correct, then there were five cat-birds not nesting, and, I should judge, all male birds. It will be remarked that I overlooked the nests of these "extra" birds. This I believe is impossible. By going over a given space—an acre at a time—prying into every nook and cranny, climbing every tall tree and searching over every small one, as well as bushes and brier-patches, it is hardly possible to overlook any nest, especially so large and conspicuous a one as that of the cat-bird. The habits, too, of non-nesting birds differ from those then breeding. They are much less restless, do not chirp and twitter, or exhibit distress when closely followed, as in the case of nesting-birds.

Having carefully examined a bird's-nest which seemed to agree most nearly with the published descriptions of such nests, I then noted each nest found and marked the amount of variation in the construction and position. Take, for instance, the nest of our very common robin (*Turdus migratorius*). Here we have a nest largely constructed of coarse twigs and grass, lined with "a cup-shaped fabric of clay or mud," this mud, again, being covered with finer grass, horse-hair, and occasionally a few feathers. This nest is an excellent one to study for degrees of variation in construction; and here note these differences. During the past spring and early summer, we found thirty-two nests of the robin in an area of about four hundred acres.

Of these thirty-two nests I will speak, principally, as to their construction, especially with reference to the care exhibited in the *mud-lining*, and refer but incidentally to the positions of the nests.

Eleven nests were what might be called "typical," following the description given by Dr. Brewer in the latest work on North American ornithology.[1] In the eleven nests the mud-lining was complete, extending to within about an inch and a half of the rim, or top of the nest. In fourteen, the mud-lining was more or less incomplete, although always extending over the bottom of the nest, i. e., so much of the interior surface as the eggs or very young birds rested upon. Without an exception, I believe, the fine grass and hair lining the interior of each nest were in greater amount in proportion as the mud-lining was imperfect; so that, in some instances, the mud being concealed, the nests were very similar to those of other thrushes. The remaining seven nests were altogether "abnormal," and, noticeably, each of these seven nests was in such position as a robin would not be supposed to select. A careful study of the surroundings, however, showed that there was always some outside advantage, such as

[1] "A History of North American Birds," by Messrs. Baird, Brewer, and Ridgway. Vol. i., p. 27. Boston, 1874.

proximity to abundant food, and this may have had some influence in the choice of location. As an instance, one of these seven nests was placed in a deep cleft in the trunk of an apple-tree. It had a southern exposure, was protected from rain by the trunk and branches of the tree, and, altogether was admirably located. But, as the tree itself had an abundance of branches, and for many summers had had nests upon it, there seemed to be some reason in the location now first occupied. What, indeed, was the cause of this change from the branches to the cleft, I could not discover. The nest itself was merely a few coarse twigs for extra support of the "clay fabric," which was placed so as to resemble a modified cliff-swallow's nest more than that of any other bird. If, now, young birds build nests through imitation, then the young robins reared in this nest will seek out somewhat similar situations for their own nests; but if such a locality did not suit the bird's mate, then a nest in a more exposed position would be built, but, I doubt not, with some of the peculiarities of the nest in which it was reared.

In comparing the eleven typical nests of the robin, it could not but be noticed that minor differences or peculiarities existed. These small variations were such as size, which was, in fact, considerable; in shape, some of the nests being rather oval than circular; in the choice of material for the interior lining, which, I am sorry to say was, in one instance, suspiciously similar to the lining of the nest of the chipping sparrow, and was probably stolen. Indeed, among robins, as well as all other birds, there are individual rogues, as well as cross-grained, scolding wives and husbands.

Taking a careful survey of the whole thirty-two nests, they suggested at once an ordinary village: there were handsome structures, such as opulence builds, and very modest ones, such as those in straitened circumstances are compelled to occupy; and, while the same causes for this variation in dwelling-places does not obtain among birds as among mankind, causes do exist among the birds, in many ways analogous. For instance, there are energetic birds and lazy ones. There are plucky birds that will overcome obstacles, and despondent ones that are easily cast down; and will not this of itself account for a great deal in the variations of birds'-nests? Can it be doubted that birds differ greatly in their temperaments? Who, that has kept canaries, has not noticed that, while some are cross, others are affectionate, others lively, and, again, others moody—that their dispositions were nearly as varied as in mankind? If it is admitted that variation in disposition exists among birds, may we not go a step farther, and claim also differences in mental ability—that, in plain language, the "smarter" bird will build the better nest? One reason why nests do not vary more than they do, simply, is—a mud-lined nest being *best* suited to a robin's welfare—that a bird reared in a poorly-constructed nest may be of greater ability and more energetic than its parents, and this, joined with the fact that the bird's mate may have been reared in a nest of perfect construction, of itself would tend to remedy, in part, the defects its partner might allow; these facts together would certainly secure an approach to, if not the complete attainment of, a "typical" robin's nest. So, as the years roll by, the nest of the robin would remain substantially the same, while the amount of variation that now exists would be perpetuated, and probably very slowly increased.

Why indeed, a robin should line its nest with mud, and a cat-bird should not, is probably past finding out, but, as changes gradually brought about by man's agency have already effected changes in the habits of some of our birds, so these same changes, ever in progress in the haunts of our robin, may cause these birds to gradually omit this lining of mud in their nests, and so make them more like the nests of other thrushes; just as the cliff-swallow, with us, no longer places a "bottle-neck" opening to its mud-built nests. There is an instability in the whole range of the habits of birds, going hand-in-hand with the undoubted tendency to variation in their anatomical details. Natural selection, or whatever may be the governing impulse that controls it, also indirectly causes the range of variation in the details of the construction of their nests, inasmuch as these variations of habit are the necessary result of changes wrought in the physical construction of the creatures themselves, for, stripped of the haze that metaphysics has gathered about it, as a bewildering gloom, we can see in the operations of the mind, in man and bird, only the curious results of the workings of those fatty atoms, intimately combined, we call the brain; and no argumentation can separate this brain and mind. They are just as interdependent, and parts of a single whole, as the eye and sight, the nose and smell, hearing and the ear, the circulation of the blood and the beating of our hearts.

II.

A nest of totally different character, that of the well-known Baltimore oriole (*Icterus Baltimore*), was more carefully studied by the writer, inasmuch as it afforded more marked variations from what may be considered a "typical" form of the structure.

Mr. Wallace has shown that, where a nest is so constructed as to conceal the sitting bird, in all such cases, the birds are of bright, showy plumage, and would be easily detected by birds of prey, if not concealed when occupying their nests. Of the family *Icteridæ*, to which our Baltimore oriole belongs, Mr. Wallace says, "The red or yellow-and-black plumage of most of these birds is very conspicuous, and is exactly alike in both sexes. (*This is not true of the Baltimore oriole, the female of which is much less brightly colored.*) They are celebrated for their fine, purse-shaped, pensile nests." There are now two considerations worthy of attention, with reference to this bird and the character of its nest. In the first place, as the male bird is much brighter in the color of its plumage, would it not require a concealing nest if it assisted in incubation? Now, does the male bird assist in covering the eggs? It unquestionably does.

Secondly, if the bird-concealing nest, a "pendulous and nearly cylindrical pouch," as described by Dr. Brewer, is constructed solely with reference to the protection of the parent-birds, would it not be within the range of probabilities that, the danger no longer existing, the labor of constructing so elaborate a nest would be abandoned. Has this actually occurred? During the summer of 1872, I found nine nests of the Baltimore oriole within a comparatively small area; in 1873, I succeeded in finding seventeen nests in an area nearly ten times in extent; and during the present summer (1874) I found thirteen nests in an area of the same extent as that examined in 1873. These thirty-nine nests I classified as follows: Of the nine nests of 1872 that I examined, six were so constructed as to effectually conceal the sitting bird, and three were sufficiently open at the top to give a hawk, hovering above it, a view of the bird.

Of the seventeen nests of the oriole which I found and inspected during the summer of 1873, eleven of them were "bird-concealing" in their shape, and the remaining six like the three I found in 1872, i. e., open at top.

During the present summer, Baltimore orioles have been unusually abundant, and, of the thirteen nests I found, eight were open at the top, and five were long, pendulous pouches, that wholly hid from view the sitting-bird.

Bearing in mind the supposed reason for building a nest that would conceal the parent birds when occupying it, I noted down the exact location of each of these thirty-nine nests. In every instance those nests that concealed the sitting bird were at a considerable distance from any house, in uncultivated parts, the larger number on an unfrequented island, the others on elm-trees growing on the banks of a lonely creek. In both of these localities, sparrow-hawks (*Tinnunculus sparverius*) were frequently seen—they are nowhere so numerous as some seventy years ago—as compared with the neighborhoods selected for the building of the open-topped nests, all of which were in willow and elm trees in the yards of farm-houses, and in full view of the people continually passing to and fro beneath them. The conclusion drawn from the study of these nests was, that the orioles, knowing there was much less (if not total) absence of danger from hawks, therefore constructed a less elaborate nest—one which answers every purpose of incubation, and yet does not conceal them when occupying it.

Of the nests that did conceal the sitting bird, every one was really open at the top, and the bird entered from above. The weight of the bird, when in the nest, appeared to draw the edges of the rim together sufficiently to shut out all view of the occupant. The rims of these nests that, when occupied, concealed the birds, were all much smaller and the nest itself deeper than in those nests where concealment was not considered in the construction, these latter being in every way much like the nest of the orchard oriole (*Icterus spurius*).

Originally, in all probability, when its enemies were more numerous, especially the smaller hawks, the nest of the Baltimore oriole was perfectly closed at the top, and with a side opening; but, of the many scores of this nest that we have met, we have never seen a nest of this bird so constructed.

The very fact of the Baltimore oriole constituting a partial exception to Mr. Wallace's supposed law of birds'-nests is, we think, here shown to be a proof of the correctness of his theory.

SKETCH OF THE LIFE OF FRANCIS HUBER.

By Mrs. S. B. HERRICK.

FRANCIS HUBER was born in Geneva, July 2, 1750. His father, John Huber, was a man of many and varied gifts; he was considered one of the wits of the day, and was an accomplished musician, poet, painter, and sculptor. The art of cutting landscapes and silhouettes from paper may almost be called his creation. He attained such proficiency in executing likenesses in this way that, with his hands behind him, he tore from a card a correct profile of Voltaire. The curious combination of talent and caprice which characterized most of his work is well illustrated by one of his attempts: he executed a profile of Voltaire, upon one occasion, by allowing his cat to bite from a slice of cheese portions which he successively presented to her! Besides his lighter social and artistic gifts, he possessed keen powers of observation as a naturalist and considerable facility with the pen, as is shown in his "Observations sur le Vol des Oiseaux de Proie," Geneva, 1774.

John Huber transmitted to his son most of his tastes, without that discursiveness and caprice which so fatally marred his own career. The boy, from his early childhood, attended lectures at the Genevan College. The library, the cabinet, and the observations of his father, early roused in him an ardent love for natural science; he had begun intelligently to observe Nature at an age when other children seem hardly aware of her existence. Before he was fifteen years old, he had completed a course of physics under De Saussure, and familiarized himself with chemical manipulation in the laboratory of a relation, who was an obstinate alchemist.

Intense application, together with the habit of reading late at night, by dim lamp-light, or even by the light of the moon, seriously impaired his health. At the age of fifteen he found himself not only utterly prostrated in strength, but threatened with blindness. His father, in alarm, took him to Paris, to consult the celebrated Tronchin, who ordered him to the country. At the village of Stani, near Paris, he led the life of an ordinary peasant-lad, following the plough, and occupying himself in other farm-work. This regimen proved efficacious, and he returned to the city in full and vigorous health.

The oculist Wenzel, after an examination of his eyes, pronounced the disease incurable. One eye was affected with the *gutta serena*, or amaurosis, the same disease which caused the blindness of the poet Milton, of which he says:

> "So thick a *drop serene* hath quenched their orbs."

The blindness of the other was caused by cataract, a disease, in our day, often successfully treated. The science of the oculist was, then, far from the perfection which it has since reached, and the operation was considered too hazardous to be attempted.

Happily, before the darkness closed down upon him, he had seen and loved Marie-Aimée Lullin, daughter of one of the syndics of the Swiss Republic. The childish love which had sprung up, at a dancing-school, between the boy and girl, grew with years into a deep and life-long devotion. In spite of the bitter opposition of her father, which amounted to persecution, Mdlle. Lullin refused to give up her lover; but Huber was filled with fears lest his growing infirmity should alienate her. Under the influence of this dread he would hardly acknowledge to himself the advance of the disease. As long as he could at all perceive the light, he spoke and acted as if he saw. The habit of expression thus formed left its impress upon his future style. One cannot read the graphic descriptions of his experiments, as given by himself, and fail to notice the frequent recurrence of such expressions as "*I have often seen*"—"*I had the satisfaction of seeing*"—or even, at times—"*I saw with my own eyes.*" There is a profound pathos in this apparent obliviousness to his affliction, when we thus trace it to its source.

These fears, however, proved groundless, for Mdlle. Lullin, as soon as she reached her majority, married him. During the forty years of their married life, her tenderness and devotion toward her husband were unfailing. She was his reader, his secretary, his observer; he said of her, in his old age: "As long as she lived I was not sensible of the misfortune of being blind."

Besides his wife, Huber was eminently fortunate in his assistant, Francis Burneus. This man, who had entered the family in the capacity of a servant, his master soon discovered to be "born with the talents of an observer. . . . It is impossible," Huber again says, "to form a just idea of the patience and skill with which Burneus has carried out the experiments which I am about to describe . . . . he counted pain and fatigue nothing compared with the great desire he felt to know the results. If, then, there be any merit in our discoveries, I must share the honor with him; and I have great satisfaction in rendering him this act of public justice."

Huber practised Burneus in the art of observation; comparing his results with those of other investigators. He directed him by a thousand questions, adroitly combined, till fully satisfied of his fidelity and accuracy. At the first issue of the book, which was the record of their joint labor, the naturalists of Europe looked askance at the marvelous revelations of bee-economy made by a blind man aided by a peasant; but, as knowledge upon the subject grew, prejudices melted away, and there is scarcely a fact recorded by Huber which subsequent investigation has not again and again confirmed.

The marvelous activity of mind, which to many men would have proved only a torment, was to Huber a source of the deepest delight. His love of music, and proficiency in the art, beguiled many hours, and added greatly to his social enjoyments. He had made himself master of counterpoint, and was able, from the dictation of the bass of a musical composition, to arrange the harmonies. The whole piece or song would be dictated to him, in this way, phrase by phrase, and a single repetition was all-sufficient.

He invented, for his own use, a printing-machine, by means of which he could correspond with his absent friends; and he was enabled to indulge his fondness for walking in the opon air by means of another contrivance of his own. He caused knotted cords to be stretched along the borders of all the rural paths around his house; by means of the cord he could guide himself, and the knots informed him what point he had reached.

Soothed by every appliance which ingenuity and ample means could afford, surrounded by the tenderest affection and the keenest sympathy in his pursuits, his darkened life was full of sweet compensations. But it is in himself, rather than in the circumstances of his life, that we find the sources of his tranquil happiness. He retained to extreme age the tenderest affection for his friends; he showed to the last the untouched freshness of delight in Nature, the boyish candor and directness, the noble enthusiasm, the quick sympathy with youth and its interests, which so generally characterize men of science, and which offer one of the most unanswerable arguments in favor of the ennobling influence of such pursuits.

"When any one spoke to him on subjects which interested his head or heart," says De Candolle, "his noble figure became strikingly animated, and the vivacity of his countenance seemed, by a mysterious magic, to animate even his eyes, which had been so long condemned to darkness. The sound of his voice had always something of the solemn. 'I now understand,' said a man of wit to me one day, who had just seen him for the first time—'I understand how young people willingly grant to the blind the reputation of supernatural inspiration.'"

Huber retained his faculties to the last. He wrote to one of his friends on the 20th of December, 1832, and two days later he sank to rest, without a pang, in the arms of his daughter, Madame de Molin, in the eighty-second year of his age.

The work, in his own department, which he has left behind him, is marvelous in its accuracy and its fullness. Facts which had eluded observers from the days of Aristomachus of Soli down to those of Bonnet, yielded to the patience, tact, and ingenuity of Huber. It is hard to decide which is most admirable in him—his life-long devotion to one purpose; the patience and caution with which he questioned and cross-questioned Nature by experiment; or the lucidity and picturesqueness of his descriptions of his work. The latter quality, it is probable, was the direct result of his deprivation. It was necessary for him, out of the disjointed answers and remarks of his observers, to form a perfect, rounded mental conception of the facts in themselves and in their relations. This perfect comprehension in great measure insures a luminous style; obscurity of style being much more frequently a result of confusion of ideas than of a mere awkwardness in the use of words.

Huber's work was first recorded in the form of a series of letters addressed to M. Bonnet, and called "Nouvelles Observations sur les Abeilles," 1792. Afterward, in the later editions, several papers on the "Origin of Wax," the "Sphinx Atropos," "Bee Architecture," and other topics, were incorporated into the same volume. Many of his experiments and observations were made at the suggestion of Bonnet, and it was upon his recommendation that Huber constructed his "single-leaf" and "book"-observing hives. The first of these was made to contain a single comb, but, fearing that the bees, who are taught by Nature to build several parallel combs, might manifest change of habit or modification of instinct under new conditions, he also caused to be made another hive, by which he could correct the observations made upon the first. This second hive was so arranged that each frame could be turned back, like a door, upon hinges.

The first observations which Huber records are those upon the fertilization of the queen. Many theories had been advanced upon this subject, by Swammerdam, Debraw, Hattorf, and others, supported by experiments which, to most minds, would have seemed conclusive; but Huber was not satisfied till he again and again repeated, with every precaution and under every condition, the experiments made by his predecessors. These experiments, made by himself and others, he describes with his usual clearness, and from them he deduces the following singular facts, which have been a thousand times confirmed:

The queen-bee, which is the only perfect female in the hive, is fecundated on the wing, and this one fecundation suffices to fertilize the hundreds of thousands of worker-eggs which she lays during her life, of from three to five years. If the impregnation of the queen be deferred until the twenty-first day of her life, she not only lays nothing but drone-eggs, but her instincts are also impaired. Perfect, fertile queens always discriminate when laying; they deposit the drone and worker-eggs in their own peculiar cells, but the queens whose impregnation is retarded are indifferent, and lay their eggs anywhere. Previous to Huber's time, it was believed that the worker-bees, like worker-ants, carry away eggs thus misplaced, and deposit them in the proper cells; but he ascertained the fact that they carry away such eggs only to devour them. By some unknown means the bees can distinguish a worker from a drone egg; and, if, by an oversight, a worker-egg is allowed to develop into a larva in a drone-cell, or *vice versa*, the bees cap over the cell with the flat or convex cover peculiar to its inmate, without reference to the size of the cell upon which they are working.

Réaumur, and most other naturalists, had believed that the queens deposit, in royal cells, a peculiar egg, which develops into a queen; but Schirach, a German clergyman, announced, toward the close of the last century, a discovery which created not a little interest. Some doubt still hung over this discovery, which was entirely dispelled by Huber's observations. Schirach stated that the bees can, by peculiar treatment, rear a queen from a worker-brood.

If a swarm of bees find itself suddenly queenless, the workers immediately select the larva of a common bee, not over three days old; they enlarge this cell by cutting down the partition-walls between it and two adjoining cells, destroying their inmates, and then they supply the remaining worm with food, differing in quality and quantity from that of the workers. The nursery of the royal heir is elongated, and finally capped over with a peculiar covering. In sixteen days after its exclusion from the egg this larva becomes a queen. From increase of space, accession of heat, and the different quality and quantity of food given to the worm, that which would have become a worker becomes a queen. By this change of treatment, its anatomy and physiology, its instincts and functions, the time necessary for its development, and the length of its life, are all utterly changed. The queen performs but one office in the hive, that of supplying her realm with subjects, while the workers perform all the multitudinous offices which the economy of the hive demands. The whole structure of the queen and workers is coördinated to their functions; she possesses the ovaries, which in the worker lie folded away in a germinal form, while they possess all the organs needed for their peculiar work—strong mandibles, powerful wings, pollen-basket, pincers, brush, wax-pockets, and honey-receptacle. Though queens are often made from worker-larvæ, Huber observed the old queen laying in royal cells, when the hive is about to throw off new swarms, and more than one queen will be required.

He also determined that some few workers, which have partaken of the royal jelly, have their reproductive organs partially developed, and lay drone-eggs. This fact was reached by an experiment which required great courage and an almost incredible patience. Burneus, of his own free will, caught, held, and carefully examined every bee of two swarms in which fertile workers were suspected. This required *eleven days* of steady labor. "During all that time," says Huber, "he scarcely allowed himself any relaxation except what the relief of his eyes required." Each bee, after examination, was transferred to a glass hive, which was watched; finally, a bee was caught in the act of laying, and was dissected: small ovaries were detected containing a few eggs, but in all other respects it was a perfect worker.

Huber also discovered the bitter animosity of the queens toward each other. He observed the first-hatched queen, as she emerges from her cell, traverse the comb till she finds a royal cell, which she tears open, in apparent fury, and then stings the helpless pupæ to death. This she repeats again and again till she has destroyed every possible rival. If, however, two queens emerge simultaneously, the bees clear a space, and stand back and watch the conflict, which must end fatally to one or the other. The two queens attack each other, but, if, during the fight, they happen to find themselves in such a position that, by closing, each would kill the other, they withdraw, and begin the combat afresh. As soon as either secures such an advantage of position that she can sting without being stung, the fatal thrust is given.

Réaumur made the suggestion that it is the queens themselves who rid themselves of their rivals; but he had been strongly opposed by the German naturalists, who contended that the worker-bees disposed of the interlopers. What Réaumur advanced as a conjecture Huber founded upon the impregnable basis of fact.

If a strange queen be introduced into a swarm possessing one of their own, the workers generally surround her, and quietly detain her prisoner till she perishes of hunger, but do her no direct injury. The only instance where workers were ever known to sting a queen was once, during a general *mêlée*, and then it seemed pure accident. If, however, the stranger queen, by accident, passes the sentinels at the door, without being challenged, or is introduced by the experimenter into the hive, for the purpose of observation upon the point, and brought into close quarters with their own queen, they insist upon a battle, and restrain the motions of either if they seem inclined to fly.

After the loss of a queen, by a swarm, if a strange queen be introduced, her reception will depend entirely upon the time which has elapsed since their bereavement. At first, they refuse to be comforted, and reject contumeliously any attempt to replace their loss. After eighteen hours, they begin to consider the matter, and, in twenty-four, receive, with royal honors, any queen offered to them.

The yearly massacre of the drones, though a well-known fact, Huber was the first to observe in its details. It was seen through a glass table, upon which a hive, deprived of its bottom-board, was placed. He also ascertained that the massacre never takes place unless the swarm possesses a fertile queen, and the swarming-season is over.

By aid of the microscope, Huber proved that the queen-bee is truly oviparous—that her eggs are true eggs. He saw the worm grow to maturity within the transparent walls of the egg, rend the pellicle, and emerge. The idea that workers brood the eggs he also dispelled, by repeated observation of the fact that the eggs hatch equally well when removed from the care of the bees, and that the workers frequently enter empty cells and remain quietly there, evidently taking repose.

His observations upon the spinning of the cocoon were made through the walls of blown-glass cells, into which the egg was removed. The drones and common bees spin complete cocoons; the royal larva, on the contrary, spins an imperfect one, enveloping the head and thorax, but reaching only to the second ring of the abdomen. This is evidently the result, not of any peculiar instinct, but of the conformation of the cell, for the royal cocoon is complete if it be spun in a common cell. In ordinary cases, if the royal cocoon were complete, it would be impossible for a queen to destroy her rivals in the state of pupæ.

By repeated experiment, he showed that the size of a cell has no modifying effect upon the development of a bee, except by retarding its growth, if it be too small: a common bee is the same size, whether reared in drone or worker cells. In determining this point, many interesting facts in regard to the instinct of queens and workers were ascertained. A fertile queen refused to lay worker-eggs in drone-cells, though evidently oppressed with them: when, however, he introduced worker-cells, artificially supplied with a drone-brood, the bees emptied the cells, and the queen laid in them, *five or six* eggs in each. With his usual judicial fairness, Huber remarks upon this inconsistency in the instinct of queens. They refuse to lay drone-eggs in worker-cells, and yet here is a queen which deposits five or six eggs in a single cell; the drone-egg in the worker-cell would produce a small though perfect drone; the five or six worker-eggs in the same cell, if they all remained there, would produce nothing.

Huber concludes, from a number of experiments made in this direction, that, though the queen knows what kind of egg she is about to lay, and so deposits it always in the proper cell, yet she does not *determine the sex* of the egg, as is believed by many of the most distinguished modern apiarians. He also found that it is impossible to compel bees to rear a worker in a common cell, if it has been supplied with royal jelly. If the colony be queenless, they enlarge the cell into a royal cell; and, if they already possess a sovereign, they destroy the worm and devour the royal jelly.

When the first great drone-laying begins, the bees construct a number of royal cells, sometimes as many as twenty-seven. In these the queen deposits eggs on successive days, so that, when she leads off the new swarm, another queen may be ready to take her place; and also, that if the swarm be vigorous enough to throw off several colonies, each may be provided with a leader. During this season the ordinary instincts of the workers seem reversed; they hinder the queen, if she seems so disposed, from destroying the royal pupæ contained in the cells.

A common bee, when it reaches maturity, makes its way, without help, out of the cell, and it is for some time too weak to fly. A queen, however, is guarded by the bees; she is closely watched, and constantly fed through a small aperture in the covering of her cell, till she has attained sufficient strength to fly. The presence of a developed and imprisoned queen is generally made patent by a peculiar note which she utters, called piping. Above the busy hum of the hive this sound may be distinguished; it seems to be the expression of her impatience at her imprisonment, and is the usual precursor of swarming.

Another note, peculiar to the queen, Huber mentions. This he calls the *vox regalis*, and he states that its utterance invariably struck the bees motionless. It has not been observed by modern apiarians, and yet the best among them do not deny the fact, because of his usual exactness and caution.

Huber describes the process of swarming in minute detail. Toward the close of the drone-laying season, when numbers of the drones, and some of the queens, have nearly attained maturity, he observed the old queen rapidly passing over the combs. She created an agitation wherever she went, which did not subside after her departure, but communicated itself to all the bees in the vicinity. Finally, the whole swarm appeared to be in a violent state of excitement, and large numbers issued from the hive with the queen at their head. During the agitation, which precedes swarming, the thermometer rises from between 90° and 97° to 104°. "This heat is intolerable to bees," says Huber; "when exposed to it, they rush impetuously to the outlets of the hive, and depart." Swarming is occasioned by excessive heat, quite as much as by an overstocked hive. The initial cause of the queen's agitation is not known, but it always communicates itself to the whole swarm, whatever its cause may be.

Queens raised from the larvæ of workers had been called mute, because the piping had not been observed in them; but Huber discovered that it was only because they are not detained in captivity. He held one in confinement, and found her piping quite as vehement as that of her sisters, reared from the beginning in royal quarters.

The instinct of worker-bees, which is usually so unerring, sometimes fails them in the most unaccountable way. Though they detect drone-eggs in worker-cells, and worker-eggs in drone-cells, they seem to be ignorant of the mistake made when a drone-laying queen deposits her egg in a royal cell, and dose the poor fellow to death, trying to make a queen of him. In his investigation upon workers, Huber discovered that they were of two kinds, wax-workers and nurse-bees: the former are larger and stronger, and possess more perfect organs for the secretion of wax than the latter, though no other difference can be detected, and this seems merely the result of being reared in smaller cells.

Swammerdam states that a blind or mutilated queen ceases to lay, and that the workers of her hive no longer continue their labors, or make any collections, as if aware that it is useless to do so; but Huber shows that this is not wholly true. One queen deprived of her four wings, and another of one antenna, continued to lay and to receive the homage of her subjects as before: but the amputation of both antennæ produced very different results. Queens, drones, and workers, when deprived of both antennæ, lose their instincts, and seem to be subject to a kind of delirium. They wander aimlessly about, are unable to direct the proboscis for the reception of food, seek the door of the hive, and soon perish. A fertile queen, besides these symptoms, which are common to all under the deprivation, drops her eggs about the comb, and manifests no recognition of, or hostility to, another mutilated queen.

The first part of Huber's work here concludes with some valuable suggestions in practical apiculture. The observations in the second part were made by the aid, first, of his wife, and afterward by his son, Pierre Huber, so well known through his investigations upon ants.

In the year 1809, a bee made its appearance before one of Huber's hives, which seemed to differ from its rightful inhabitants only by a darker and less downy coat. Violent contests took place every day between the native and the alien bees. Aristotle mentions "a black bee which is called a thief," but Huber seems never to have heard this suggestion, and supposed them to differ from his own bees in some physical particulars. He, therefore, submitted them to Mdlle. Jurine for dissection, and she discovered not only in them, but in all workers, ovaries—a fact which entirely overturned the theory of neuters which had held its ground for so many centuries. The worker is not sexless, but is an imperfectly-developed female. This discovery throws some light upon the wonderful change made by physical conditions in the development of the worker-larvæ. With ordinary cell and food, the worm develops into an insect possessed of feminine instincts, in the provision which she makes for the young, and for the future needs of the swarm; while, with the larger cell and different food, the same larva would develop into a physically perfect female, which, at the same time, is wanting in all maternal instincts—a divergence which is undoubtedly one of the most marvelous in Nature, but a divergence only, not a contradiction!

The senses of bees were the next subject of investigation, and we will give, in brief, the results which Huber reached. The lenses of the bee's eyes are not adjustable; and, though they can see accurately to great distances, they seem blind to objects close by. Bees dart down to the door of their hives with a precision which is generally unerring, but, if, from any cause, they miss the opening, they are obliged to rise in the air, in order to take another observation.

If bees hear—which is a doubtful question, the old-fashioned "tanging" to the contrary—they certainly hear only what affects their welfare. Their sense of taste is also far from perfect, foul ditch-water being often preferred by them to limpid streams, or even dew, and ill-smelling plants having quite as much attraction as sweet ones; it is the quantity, rather than the quality of their food, for which they care. They are also fond of the secretion of the *aphides*, the milch-cattle of the ants.

Their sense of smell is very keen; the presence of honey they detect, even in the most carefully-concealed places. Honey-bees often, in scarce seasons, attack the bumble-bees on their return from the fields laden with honey, and force them to disgorge all they have collected. Its presence in the honey-bag must have been detected by the sense of smell. The seat of this sense is in the mouth; this Huber determined by presenting successively to all parts of the body, on camel's-hair pencils, odors especially repugnant to them. When held near the mouth, the bee started back as if annoyed. On one occasion he mixed honey with camphor, which they especially dislike; by some means they managed to separate and remove all the honey, leaving the camphor untouched.

The sense which seems to be most perfect in these little creatures is that of touch, and that seems to reside wholly in the antennæ. Greetings, caresses, and the communication of intentions, are always effected, by one bee toward another, by crossing their antennæ. It must be remembered that no light enters a hive under ordinary circumstances. "The bee," says Huber, "constructs its comb in darkness; it pours its honey into the magazines, feeds its young, judges of their age and necessities, recognizes its queen, all by aid of its antennæ, which are much less adapted for becoming acquainted with objects than our hands. Therefore, shall we not grant to this sense modifications and perfections unknown to the touch of man?"

In order to determine the means of communicating ideas which exist among the bees, Huber divided a hive into two parts by a fine wire grating; the bees on both sides of the grating continued their work tranquilly, collecting honey, storing pollen, and building no royal cells. It was again divided by two parallel wire gratings, which admitted communication by means of every other sense except touch. The queenless half of the swarm fell into their usual distress and agitation, and soon set about constructing royal cells. By other experiments he determined the fact that these insects recognize their queen, and communicate the fact of her presence, by the crossing of their antennæ with those of other bees. The effect produced by the amputation of the antennæ has been already described, and shows of what vital importance this organ is to them.

Huber made many experiments upon the respiration of bees, proving them to absorb oxygen, and emit carbonic acid. A number of live bees expired instantly in mephitic air; but others, when exposed to it in a torpid condition, were unaffected, showing that it was *respiration*, not *contact*, which caused their death. Two stigmata, the respiratory organs of insects, were discovered by Huber in addition to the two already known. Eggs and larvæ, he showed, also absorb oxygen and evolve carbonic acid. The air of the hives was repeatedly examined by Huber, and found to be very nearly as pure as the outside air. This fact directed his observations more closely to the economy of the hive, and he discovered that the bees maintained a systematic ventilation. Files arrange themselves in lines radiating from the door, and, by keeping their wings in rhythmical motion, generate currents of air. If the hive be sealed up, the bees at first fan violently, but in forty-five minutes the whole swarm lies apparently dead from suffocation.

It is necessary to pass over the curious provisions made by them against their enemy the *Sphinx atropos*, and Huber's discovery of the origin of propolis, to the last point which he has made luminous by his observations, the origin of wax, and its use in bee-architecture. Réaumur discovered that pollen-dust, when submerged in water, swells and finally bursts, and from the grains exudes an oily liquor, which he took to be the substance converted, in the body of the bee, into wax. This had been so long an accepted fact, that Huber did not doubt its correctness till an observation of Burneus's induced him to make a series of experiments upon the subject. He confined one swarm of bees, giving them only honey, and another, supplying them with nothing but pollen. Seven times new comb was found in the first hive and removed, while none at all was made in the second. Wax is secreted like fat in other animals, from saccharine matter, and it accumulates, in layers of delicate white spicules, in the wax-pockets of the bees. There are six depressions, lined with a reticulated membrane, in the lower side of the worker's body, between the abdominal rings.

The reason for gathering pollen was, then, a matter of interest. It was manufactured not for food, as bees lived perfectly well without it. By close scrutiny Huber discovered that the workers swallow the pollen, and after a time regurgitate it as food for the larvæ. Marked bees were seen to partake of the pollen, to ascend to the nurseries and plunge their bodies head-foremost into the cells, containing worms. After their withdrawal the cells were examined, and found to contain a supply of the jelly which constitutes the food of the larvæ.

Huber sums up the conclusions of all his experiments upon wax:

"1. That the wax comes from honey.

"2. That the honey is also a food of the first necessity for bees.

"3. That flowers do not always contain honey, as has been imagined; that this secretion is subject to the variations of the atmosphere, and that the days when it is abundant are very rare in our climate.

"4. That it is the saccharine part of the honey which enables the bees to produce wax.

"5. That raw sugar yields more wax than honey, or refined sugar.

"6. That the dust of the stamina does not contain the principles of wax.

"7. That this dust is not the food of the adult bees, and that they do not collect it for themselves.

"8. That the pollen affords the only aliment which is proper for the young, but that this substance must undergo a peculiar elaboration in the stomachs of the bees, to be converted into an aliment which is always appropriated to their sex, their age, and their wants; since the best microscopes do not show the particles of pollen or their coverings in the liquor prepared by the working-bees."

The bees, when wax is needed, gorge themselves with honey, and hang suspended in festoons or curtains for about twenty-four hours. During this repose, which Réaumur supposed was for rest and recuperation, the honey is digested and the wax makes its appearance partially under the overlapping rings of the abdomen. No other organ for the secretion of wax was found by the exquisite dissections of Mdlle. Jurine, or any of her successors, except the cellular lining of the pockets.

These scales a worker disengages by means of the pincers on its legs, and seizing the scale in its mouth. "We remarked," says Huber, "that with its claws it turned the wax in every necessary direction; that the edge of the scale was immediately broken down, and the fragments, having been accumulated in the hollow of the mandibles, issued forth like a very narrow ribbon, impregnated with a frothy liquid by the tongue. The tongue assumed the most varied shapes and performed the most complicated operations; being sometimes flattened like a trowel, and at others pointed like a pencil; and, after imbuing the whole substance of the ribbon, pushed it forward into the mandibles, where it was drawn out a second time but in an opposite direction."

These particles of wax thus rendered adhesive, ductile, and opaque, by working in the mouth, were applied to the vault of the hive. A wall of wax was begun in an inverted position, depending from the top of the hive, by this bee, which is called the founder-bee. When its store of wax is exhausted, another bee follows and proceeds in the same way, guided by the work of its predecessor. When the wall was nearly an inch in length, and about two-thirds as high as the depth of an ordinary cell, the bees began excavating a cell on one side, and two on the other; these cells were so arranged that the partition-wall between the two cells was exactly opposite the middle of the one.

Bees, Huber tells us, do no truly coöperative work; the only thing which looks like coöperation is the unanimity with which the whole swarm waits till one bee has laid the foundation. Each bee follows the suggestion of the one which has preceded it. As the work progresses, it becomes possible for a larger and larger number to join in, and it is only the foundation-cells which are excavated; the others are built in their permanent form.

The much-praised exactness of the bee is shown to have been over-estimated; but the variations which we find in the hive are much more extraordinary than the uniformity. These are always due to something wonderfully like the intelligence of man, in its power of conforming to circumstances.

Only once in his life was Huber turned aside from his peculiar work. In his investigation upon the ventilation of the hive, he had occasion to introduce some seeds, and watch their germination. At the suggestion of Senebier, whom he had associated with himself in these particular experiments, he turned his attention to the phenomenon of germination, and, in connection with him, prepared a paper entitled "Mémoire sur l'Influence de l'Air dans le Germination des Grains," Geneva, 1801, but he soon returned to the work of his life.

No more striking commentary can be made upon the extent of Huber's labors than that afforded by a consideration of the work of his successors. The German apiarian Dzierzon has cleared up the mystery of the drone-laying queens—a mystery fully recognized and clearly stated by Huber. Many facts have been added to those discovered by Huber, and some few corrections of his statements have been made; but it has fallen to the lot of few naturalists to leave behind them a work so full and accurate as his. All that has been done in this department since his time—and, altogether, it falls short of the work performed by him—is merely a building upon his foundation.

The discoveries which he made are recorded, in full, and are supported by experiments, described with such lucidity, that to read them is almost like witnessing the facts. His clear, unerring intellect, penetrating through all side-issues, seized the gist of every difficulty; and those which he did not finally solve, he stated with such accuracy as to direct the observation of his successors.

CORRESPONDENCE.

ALLEGED FALLACIES OF SCIENCE—CAUSE AND EFFECT—MODES OF FORCE.

To the Editor of the Popular Science Monthly:

DR. JOHN W. DRAPER'S "History of the Conflict between Science and Religion" should be read by every searcher after truth. But Dr. Martineau's address in London, last fall, on "Religion as affected by Modern Materialism," considered in connection with Dr. Draper's book, portends danger to the dogmatic assertion of mere hypotheses, or guesses, as scientific facts. Enlightened people are fond of sensation as a pastime, but, in the serious and desperate conflict which is surely approaching, they will accept neither superstition nor sophistry, but only mathematical truth or pure logic. Scientific imagination, useful in research, should not be allowed to culminate in illogical speculation. Phenomena are effects: and not their causes, but only their correlates or conditions under which they occur, lie in the field of physical science.

Physical force is not the *cause* of physical action. Specific modes of force have no physical existence, *but are only in thought* correlatives to phenomena. Gravity is not the cause of the persistent movement of cosmical bodies, nor of their relative positions to each other, nor is it a physical "thing;" it is only one of the many correlates in thought, of the ever-changing relative positions of these bodies.

Physical force or pressure has no generalized mechanical equivalent. Like quantities of mechanical effect, due to like quantities of any mode of force, *are limited to exact conditions.*

The fact that mere physical force or pressure is not the *cause* of motion, and has no quantitative equivalent in mechanical effect, is mathematically demonstrated thus:

Under the gravity or pressure of the atmosphere—fifteen pounds to the inch—water has a velocity of forty feet per second, and steam, or other gas of like density, a velocity of 1,600 feet. Hence, considering the relative velocities and masses, the mechanical effect observed with reference to the gas is forty times that with reference to the water, *both substances acting under the same pressure during the same time.* (Space, never having been alleged to be a *cause*, is purposely neglected in this calculation. As a correlate of phenomena, it will form the subject of a future communication.) These varying effects obtain whenever unlike masses move under *like qualities* of constant force. Therefore, as cause equals effect, the mechanical effects, proportional to mass, being quantitatively different under the same force, they cannot be caused by the pressure or force under which they act.

Hence, that scientific imagination which treats modes of force as causes, and from this hypothesis, and exactly conditioned experiments, generalizes the quantitative equivalent effect of any one mode—as the "mechanical equivalent of heat"—and from similar hypotheses calculates the densities, temperatures, etc., of other worlds than ours, is not in accordance with mathematical demonstration, and is, therefore, a delusion. "Promise and potency" are causes, and, as Prof. Tyndall very properly says, are discerned in matter; and, being *absolutely known*, they are not susceptible of proof. But their effects, being only observed, and therefore conditioned, are susceptible of both proof and prediction from knowledge of the several conditions under which they arise. Pure science adduces not the causes, but only these conditions of phenomena.

The times portend a crisis in one of Mr. Herbert Spencer's rhythms which has long been setting in, laden with sophistry, miscalled expediency, and general demoralization. Let pure science, resolutely, but carefully, take advantage of its ebb.

A. ARNOLD

TENAFLY, N. J., *December* 28, 1874.

EDITOR'S TABLE.

TYNDALL AND HIS REVIEWERS.

WE print in full the masterly reply of Prof. Tyndall to the attacks of his critics, which is prefixed as a preface to a new edition of the Belfast discourse. It was not to be expected that he would remain passive under the unscrupulous assaults to which he has been subjected; nor that, when he did speak, he would make any half-way work with his assailants. Our readers will agree that they have got no more than they deserve; and we think that every competent reasoner must admit that Prof. Tyndall's rejoinder to the main charges against his address is conclusive.

In regard to the wisdom of opening and pursuing this important question, there can, we think, be no serious doubt. It can be condemned only by condemning the general desirableness of discussion, the analysis of opinions, and the comparison of conflicting views. It has been wisely said that of the three states of mind, or stages of conviction—the unanimity of the ignorant, the disagreement of the inquiring, and the unanimity of the wise—the second is at all events the parent of the third. He who drags people out of the slothfulness and stagnation of ignorant unanimity, even though thinking engenders discord and dispute, is doing a wholesome and necessary work. This is what Prof. Tyndall has very successfully accomplished. If to concentrate public attention upon a subject of great and acknowledged importance, to summon the most powerful minds to its re-examination, and to secure the keenest scrutiny into all its aspects and bearings, be the way to arrive at its clearer understanding, then has the author of the Belfast address done an eminent service to his generation. Such services are always useful, but they become of high and especial value when the problems brought forward are new, or are old problems which have acquired new meanings by a change of the circumstances in which they are considered. The critics of Prof. Tyndall tell us that he has raised a very old question, one which comes up alike in every age, which is no nearer a settlement now than it was thousands of years ago, and which is just as insoluble for modern science as for ancient theology. But it is not easy to understand how the mere calling up of an obsolete and hopeless question, that derives no new significance from the present state of knowledge, should have made so profound an impression upon the strongest minds, in widely-separated countries, and in this age of absorbing intellectual activity. A startling statement may arrest momentary attention, but, if empty and futile, why should its interest be so sustained? For three months after the delivery of Tyndall's address we were deluged with comments, dissections, exposures, and refutations by the daily and weekly press, and, had it been as vacant of vital meaning and pertinent application as many allege, its force would long before this have been spent, and the subject would have died away as a mere superficial and transient excitement. But things have gone quite differently. The interest has increased rather than declined, and to the rattle of newspaper musketry begins now to succeed the roar of the monthly and quarterly artillery. And this for the adequate reason that new elements are at work, old questions are reshaped, and appear in new relations, while the controversy takes on an aspect that it never presented before, and requires to be searched and sifted in all its issues and implications. The stage of uninquiring agreement has been passed, discussion has elicited a wide diversity of opinions, but the ultimate tendency cannot fail to be toward a more enlightened harmony of views. The critics of Prof. Tyndall of course differ with him, but their differences among each other are no less marked, and their positions are often mutually destructive of each other. It will be instructive to call attention to some of the indications of conflicting opinion and converging advancement, exemplified by the later and more carefully-considered criticisms.

We have now before us three-ably-written articles, called out by Prof. Tyndall's address: one in *Blackwood's Magazine* for November, entitled "Modern Scientific Materialism;" another in the *Penn Monthly* for December, by R. C. Thompson, who aims to answer the question, "What would Tyndall be at?" and a third in the January *International Review*, entitled "Ideas in Nature overlooked by Dr. Tyndall," which was contributed to that periodical by Dr. McCosh.

The first thing that strikes attention in perusing these papers is their substantial agreement in regard to the doctrine of Evolution. Dr. McCosh says: "Two great scientific truths have been established in this century. One is the doctrine of the conservation of energy. . . . the other great doctrine is that of development, acknowledged as having an extent which was not dreamed of till the researches of Darwin were published." The writer in the *Penn Monthly* is less explicit, but he assumes the principle, and would have no quarrel with it under a theistic interpretation. In fact, it is this which he contends for, and, without denying the process, is only inclined to belittle it. Of man he says: "His animal nature may or may not have owed its existence to the same process of Evolution that has brought forth each higher species from that below it. We think the question not worth a half of one per cent. of the ink and paper that have been wasted upon it. The motive of many, if not of most, of the denials might fairly be traced to a certain Neoplatonist contempt of the animal creation, which has no right to shelter itself behind the Bible. Moses's story of the origin of our animal nature is humbling enough; not less so if we construe his words as declaring its direct creation from the dust, than if we suppose that it passed through more elevated forms of existence before it attained its uprightness of stature and dignity of position. If Mr. Darwin teaches us the reality of our kinship on one side with the lower forms of life, and stirs in our hearts the feelings that that kinship should excite, he will not the less, but the more, fit us to claim a higher kinship with Him who giveth grace to the humble." Friend Thompson may be unhesitatingly "counted in" on the Evolution question, for he has evidently "conquered his prejudices" on the point of a low animal ancestry, and when this is done all the rest is comparatively easy. The writer in *Blackwood's Magazine*, so far from finding difficulty with the doctrine, takes to it admiringly. He says: "We have no quarrel with the evolutionary hypothesis in itself. It is an inspiring conception to look upon Nature in all its departments as intimately linked together from 'primordial germ' to the most fully-developed organism—from its rudest speck to its subtlest symmetry of form, or most delicate beauty of color. The idea of *growth and vital affinity* is, we readily grant, a higher idea than that of mere *technic* after the manner of men. There is no call upon us to defend the imperfect analogies by which past generations may have pictured to themselves the works of Nature."

This is a large concession, and indicates an immense step forward in man's view of the nature of the surrounding world. And it well illustrates the three phases of opinion to which we have referred, for there was first a long unanimity of ignorance, then a stormy and obnoxious conflict, and this has led to a new and more intelligent basis of agreement. But, while there is a virtual accord among our writers as to the doctrine itself, they disagree radically as to its interpretations, and show us that there must be a good deal of warm work yet before old beliefs are brought into consistency with the new theory. The writer in the *Penn Monthly* refuses to modify his notions about breaks and new beginnings in the order of things. He says: "If there be one word more intolerable than another to science, it is *beginning*. To disprove supposed beginnings, to show that they were the outcome of what went before, is the scientist's vocation. The category of cause and effect becomes, through long practice, his first law of thought, the groove of all his mental operations. With whatever fact he is brought face to face, his first impulse is to apply that category 'to account for the fact,' as he calls the process. And when he speaks of causes he comes to mean only secondary causes, those that are themselves effects. On the other hand, this word *beginning* seems to us to embrace in it all that the metaphysician, the theist, and the Christian, have to fight for against the naturalist." But this conception of the government of the world, "all that the theist and the Christian have to fight for," the writer in *Blackwood* regards as a very derogatory view of the divine working. He says of scientific men: "It is impossible for them, or for any, to conceive too grandly of Nature, or of the unbroken harmony and continuity of its movements. The very magnificence of its order is only a further illustration of Divine wisdom; for surely the very thought of a Divine mind implies the perfection of wisdom, or, in other words, of order, as its expresssion. The more, therefore, the order of Nature is explained, and its sequences seem to run into one another with unbroken continuity, only the more and not the less loftily will we be able to measure the working of the Divine mind."

Again, these writers come into sharp collision over the question of the atomic theory. There has been much complaint that Prof. Tyndall did not take up for discussion some special scientific topic which he had made his own; yet he did exactly this thing. His discourse is a monograph on that part of physical philosophy which he has been compelled during all his scientific life to study, that is, the evidence and import of the doctrine of the atomic or molecular constitution of matter. This is a problem which scientific men cannot evade: they are driven to it by the very exigencies of mental action; as Dr. McCosh well observes: "We seem to be obliged by a sort of necessity of thought or speech to fall back on some such conception. If every thing we see in the world be composite, and capable of analysis and division, we have to think and talk of something indivisible and undecomposable, which we may call particles, molecules, or atoms." But if the idea is thus fundamental and deals with the very essence and core of scientific philosophy, Prof. Tyndall certainly did not go out of his sphere in considering it. And though he is condemned, there appears to be no common ground for censure. His critics are as much at variance with each other as they are with him. The writer in the *Penn Monthly* attacks the atomic theory at the outset as if it were some sort of a religious enemy which must be got out of the way; and he scouts it as an unprovable hypothesis, bad metaphysics, and which explains nothing. On the other hand, the writer in *Blackwood* declares it to be "a perfectly valid theory, resting on its own evidence," and adequate to explain the physical origin of the universe; while Prof. Clerk Maxwell, according to Dr. McCosh, "discovers, in the very nature and properties of a molecule, a proof of design," thus making the atomic theory a help to religion by furnishing evidence of the existence of God.

It is a noteworthy circumstance, as showing the growth of a better state of mind, that the writers we are considering agree in abstaining from the charge of materialism, which has been so freely indulged in by others against Prof. Tyndall. They know that it cannot be maintained; but, while refraining from the imputation of "gross materialism," it is still implied that he must be some sort of a materialist. The writer in the *Penn Monthly* expressly acquits him of the charge as usually construed, by saying, "Prof. Tyndall is not a materialist of the school of De la Mettre and Holbach." He then puts the question, "In what sense, then, is Prof. Tyndall a materialist, if he be one at all?" and replies: "In the sense of being a *naturalist*;" and this term is again used in a vague and unusual sense. But it were better to have allowed Prof. Tyndall to explain his own position, which he has done in the most explicit manner. It is now generally understood, as the writer just quoted implies, that the term "materialism" is used with different significations, and Prof. Tyndall has qualified the form of it which he maintains as "scientific materialism." This consists simply in ascribing higher powers and possibilities to matter than hitherto, and not in sinking mind in matter, or in asserting the materiality of mind in the name of scientific authority. In an address, delivered before the mathematical and physical section of the British Association held in Norwich, in 1868,[1] Professor Tyndall took exactly the same ground that he assumed last August at Belfast; and passages from the discourse were widely quoted at the time as containing the most decisive disavowal and disproof of materialism in its usually accepted sense. Our reviewers should have reproduced the following portion; and, as they have not, we supply the omission:

"The relation of physics to consciousness being thus invariable, it follows that, given the state of the brain, the corresponding thought or feeling might be inferred; or, given the thought or feeling, the corresponding state of the brain might be inferred. But how inferred? It would be at bottom not a case of logical inference at all, but of empirical association. You may reply that many of the inferences of science are of this character; the inference, for example, that an electric current of a given direction will deflect a magnetic needle in a definite way; but the cases differ in this, that the passage from the current to the needle, if not demonstrable, is thinkable, and that we entertain no doubt as to the final mechanical solution of the problem. But the passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought, and a definite molecular action in the brain, occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass, by a process of reasoning, from the one to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated, as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, 'How are these physical processes connected with the facts of consciousness?' The chasm between the two classes of phenomena would still remain intellectually impassable. Let the consciousness of *love*, for example, be associated with a right-handed spiral motion of the molecules of the brain, and the consciousness of *hate* with a left-handed spiral motion. We should then know when we love that the motion is in one direction, and when we hate that the motion is in the other; but the 'why?' would remain as unanswerable as before.

"In affirming that the growth of the body

[1] This interesting discourse has been added as an Appendix to the last American edition of the Belfast Address.

is mechanical, and that thought, as exercised by us, has its correlative in the physics of the brain, I think the position of the 'materialist' is stated, as far as that position is a tenable one. I think the materialist will be able finally to maintain this position against all attacks, but I do not think, in the present condition of the human mind, that he can pass beyond this position. I do not think he is entitled to say that his molecular groupings and his molecular motions *explain* every thing. In reality, they explain nothing. The utmost he can affirm is the association of two classes of phenomena, of whose real bond of union he is in absolute ignorance. The problem of the connection of body and soul is as insoluble in its modern form as it was in the prescientific ages."

And so it turns out that he who has been buried under a mountain of execration for using science to drag the world into the abyss of materialism, is precisely the man who has demonstrated that no possible extension of science can ever lead one step toward that dread abyss. He has taught us that if science could attain perfection and predict the movements of all the atoms of Nature for thousands of years to come, as it now predicts eclipses, it would not be one whit nearer the solution or explanation of the mystery of the relation of mind and matter than it was in its infancy.

Referring to the admission in the foregoing passage, that "we cannot see any nexus between cerebral action and thought, or discover why a movement of the brain should lead to mental exercise," Dr. McCosh says, "But this was never intended to mean much." What right has Dr. McCosh to assume that Prof. Tyndall means less or other than what he says? His words are certainly not obscure, and we think they are weighty with meaning; so weighty, that it is only by an imputation of insincerity or equivocation that their effect can be escaped. Had they been generally heeded, or had Prof. Tyndall's reviewers been candid enough to make them widely known, we should have heard a great deal less vituperation of the Belfast address.

SCIENCE AND SOCIAL REFORM.

It is well known that the ground taken in this periodical in regard to the scope and influence of science is, that both as a mental method, and by the actual knowledge it furnishes, it is destined in the future to exert a growing and powerful control over public questions which have hitherto been but little, if at all, affected by it. The frantic efforts made by many to keep science in its old physical grooves, and prevent its "encroachments" upon departments of thought thus far dealt with by non-scientific methods, are doomed to certain failure. An excellent exemplification of this tendency is now furnished by the woman question. It has latterly come into prominence in various aspects as a practical reform, and the most radical and momentous changes are demanded, both in the view to be taken of the feminine nature and capacities, and in the social and public regulations to which women have been amenable in the past. The promoters of this alleged reform are generally philanthropists, sentimentalists, and politicians, who, starting from existing and acknowledged evils in society by which women suffer, rush on to the advocacy of sweeping changes, as if society had but to swallow their panaceas, and its evils would disappear. That there is a scientific side of the subject, of the greatest importance, these people never seem to suspect. It is observable that into the literature of the movement science has, thus far, hardly intruded, and little disposition is evinced to seek its assistance. We cannot, however, expect that people will be very eager to turn their backs upon their own methods of thought; and our professed reformers have their own well-settled methods. In the present case, certain political assumptions are made, and certain beliefs postulated, regarding feminine character, and from these a reformatory policy is deduced and hotly urged for immediate adoption. This was the course of even so trained a thinker as Mr. Mill. He brought his resources of philosophy and logic to bear upon the subject, and gave to the reformers their text-book; but he went on as oblivious of science as if such a thing had never been heard of. And yet the fundamental questions of this important movement belong solely to scientific investigators. Politicians, philanthropists, and logicians, will grope blindly and strike wildly in treating it, until Science has instructed them in its phenomena and laws, and shown them what voice Nature has in the decision of their questions. Politicians do not seek this information, nor care for it, when it is thrust upon them; but, all the same, the question must finally be determined by it. As we have said again and again, the missing factor, in its current discussion, has been a scientific exposition of the peculiarities of the feminine nature, and this absent factor is at the foundation of the whole inquiry. But the discussion is already beginning to turn in the scientific direction. The appearance and large circulation of Dr. Clarke's books, and the perturbations and reactions they have produced, show that this bearing of the subject is beginning to be appreciated. We have recently published two excellent contributions, written by ladies, which quietly assume the scientific point of view, and recognize its controlling importance. They even treat this delicate and serious subject in the light of the most advanced speculations, against which many have an intense repugnance, and thus testify that the question can only be settled on the basis of reason, fact, and natural law. Other essays have been sent us with varying merits, which we have been compelled to decline for want of room, and because we aim to represent that scientific side of the subject which fails to find expression in other magazines. And now we ask the careful attention of our readers to the article of Dr. Van De Warker, in the present MONTHLY, on "Women in Relation to the Professions and Skilled Labor." The mode of considering the subject adopted by this writer is what has long been wanted; and his facts and conclusions should be well pondered by those who are vehemently advocating "revolution" in the social and industrial relations of women. Philanthropy is an excellent thing if duly enlightened; measures of relief are desirable if wisely conformed to facts; and therefore the first thing is to hear what Science has to say as to the fundamental conditions upon which all genuine and permanent reform must depend.

AN ELECTRO-MEDICAL HUMBUG.

THERE appeared, in THE POPULAR SCIENCE MONTHLY of February, 1873, an article entitled "Is Electricity Life?" taken from the English *Belgravia Magazine*. Its admission to our pages was an editorial inadvertence, the article having been glanced at in haste, and only the first portion of it read. Its object, however, was to puff a quackish device of magnetic chains and bands, to be worn for the cure of nervous diseases. They were first called "Pulvermacher's Rings," and, having now been revived as "The Voltaic Armadillo," they are advertised as indorsed by THE POPULAR SCIENCE MONTHLY. The advertiser says that the most eminent medical men of Europe and America approve their use, but none of their names are given, the sole authority quoted being the foreign writer in this magazine. Now, the publication of that article was a blunder; and the article itself is worthless and absurd: and if all editors, who happen to have been, at some time, the victims of careless oversight will copy this paragraph, they may help to protect a great number of stupid people with "rheumatics" and "neurology" against being humbugged.

LITERARY NOTICES.

The Native Races of the Pacific States of North America. By Hubert Howe Bancroft. Vol. I. Wild Tribes. 797 pages. Price, $5. D. Appleton & Co.

If it be true that "the proper study of mankind is man," it is equally true that mankind has shamefully neglected its lessons. There is, perhaps, no great subject upon which the knowledge attained is so scanty, chaotic, and misleading, as that relating to the different sorts of humanity, or the races and varieties of mankind. Into the cause of this it is not necessary here to enter, but it is probably connected, in an intimate manner, with the laws of growing intelligence. Until there arises some perception of the value of knowledge, of the relation of facts to principles, and the importance of valid generalizations, there will be no such thing as accurate, methodical observations, and the systematic collection of the data requisite for the formation of intelligent opinions. The unfilled gaps in "Spencer's Tables of Descriptive Sociology" give us the most striking illustrations of the deficiency of trustworthy information regarding the characters, habits, and peculiarities, of the different tribes of men. It is a matter of great importance that these deficiencies should be supplied, and the prominence which ethnological studies have latterly assumed, as a part of the general progress of science, gives assurance that the subject will be less neglected in the future. We have reached a stage in the growth of knowledge concerning the social relations of men which makes it necessary to have the elementary facts exhaustively collated, carefully digested, and thrown into conveniently-accessible forms for general reference and study.

This necessity has been distinctly seen by the author of the work before us. For many years a resident of San Francisco, in the midst of decaying races and the relics of old civilizations, he was attracted to ethnological problems, and saw the importance of making the subject a matter of comprehensive study. He has devoted twenty years to this task, the result of which is a work of encyclopedic scope, the first volume being devoted to the wild tribes of the Pacific region of North America, and this is now published. The second volume will treat of the civilized nations, to be followed by three volumes on the Mythology, Languages, Antiquities, and Migrations of the races and tribes that are embraced within his scheme. Of the thoroughness with which Mr. Bancroft has carried on his work, the following extracts from his preface give a good intimation:

"To some it may be of interest to know the nature and extent of my resources for writing so important a series of works. The books and manuscripts necessary for the task existed in no library in the world; hence, in 1859, I commenced collecting material relative to the Pacific States. After securing every thing within my reach in America, I twice visited Europe, spending about two years in thorough researches in England and the chief cities of the Continent. Having exhausted every available source, I was obliged to content myself with lying in wait for opportunities. Not long afterward, and at a time when the prospect of materially adding to my collection seemed any thing but hopeful, the 'Biblioteca Imperial de Méjico,' of the unfortunate Maximilian, collected during a period of forty years, by Don José de Maria Audrade, *littérateur* and publisher of the city of Mexico, was thrown upon the European market, and furnished me about three thousand additional volumes.

"In 1869, having accumulated some sixteen thousand books, manuscripts, and pamphlets, besides maps and cumbersome files of Pacific coast journals, I determined to go to work. But I soon found that, like Tantalus, while up to my neck in water, I was dying of thirst. The facts which I required were so copiously diluted with trash, that to follow different subjects through this trackless sea of erudition, in the exhaustive manner I had proposed, with but one lifetime to devote to the work, was simply impracticable. In this emergency, my friend Mr. Henry L. Oak, librarian of the collection, came to my relief. After many consultations, and not a few partial failures, a system of indexing the subject-matter of the whole library was devised, sufficiently general to be practicable, and sufficiently particular to direct me immediately to all my authorities on any given point. The system, on trial, stands the test, and the index, when completed, as it already is for the twelve hundred authors quoted in this work, will more than double the practical value of the library."

Of the spirit in which the work has been executed we may say that the writer's main object has been to make it trustworthy and valuable for the use of students. He is evidently a most painstaking and conscientious worker, and is constantly careful to give the authorities for his statements. Although not without his own views upon the various questions which arise, he is not dogmatical, and puts his reader in full possession of the grounds upon which his judgments are formed. It may be added that, though the present volume contains a great amount of information which might be supposed to be dry and unattractive, its pages are nevertheless extremely readable; and, to those who have any interest in ethnological inquiries, they will have a strong fascination.

Report of the Commissioner of Agriculture for the Year 1872.

The recent reports of the Department of Agriculture show, we think, considerable advance on their predecessors. The Statistical Division is the work of six thousand collaborators. The entomological report, by Townsend Glover, who is himself scientist, artist, and engraver, is a really able exhibit of the *Diptera* or flies, from the great bot-flies, to the diminutive wheat-midge, which caused a loss in the cereals to the State of New York in 1854 of $15,000,000! Ryland Brown, the chemist, gives analyses of vegetables, soils, and fertilizers, etc. The report of George Vasey, the botanist, contains well-worked papers on arboriculture, especially on the cinchona, a tree which yields the Peruvian bark, and from which is obtained quinine. Thomas Taylor details exhaustive work as a microscopist on the fungi which produce the pear-blight, and the yellows in the peach-tree. The epizooty, fish-culture, and forest cultivation on the Plains, receive attention. There is also a good report on industrial education, etc., etc. The whole report gives evidence of painstaking work in the field of agriculture, and the results given are practical to a degree. The article by Prof. James Law on "Influenza in Horses" deserves circulation as a separate document.

Insanity and Disease. An Address before the Oneida County Medical Society, October 13, 1874. By L. A. Tourtellot, M. D., Utica, New York.

The question of the relation of mind and body, while it has a profound interest for the speculative thinker, takes on a more practical aspect to the physician. Yet it is true that this practical urgency of the problem to the medical man is the chief cause of the more rigorous scientific investigation which the subject has received in the present century, and which has revolutionized the older views that were entertained concerning it. But the question may be properly raised whether this revolution has not proceeded too far, and led to indefensible extremes of doctrine as a reaction from the absurdities of the older belief. We understand this to be substantially Dr. Tourtellot's ground in this able address. He says: "During the middle ages and down nearly to the present century the secondary and inferior nature of matter as compared with mind was a doctrine almost undisputed in the world of learning. This doctrine is reflected in the sentiment which despised and contemned the human body and discouraged the studies of physiology and pathology. It followed also that bodily diseases were attributed to sin or to possession by evil spirits. Mental disorder especially was considered a disorder of the soul, and moral insanity was thought to demand punishment rather than to excuse from it. It is easy to see how such a belief operated to cause that abuse and neglect of the insane which so long prevailed. Its evil effects upon society also appear in the monastic rules, the severe penances, and the thousand extravagances of religious fanaticism which history records."

The reaction from this doctrine, beginning in that higher respect for matter which modern science inculcates, professes to base itself upon the results of physiology and pathology, and propounds the view that mental disorder is in all cases simply a bodily or brain disease. The implication is that mind, in its normal or usual manifestation, is a cerebral function, and this is held to necessitate the inference that abnormal mental manifestations are caused only by physiological derangement. This is the ground taken by that eminent alienist Dr. Maudsley, and Dr. Tourtellot admits that, however great may be the want of evidence to establish the theory, it is at least a consistent position. Dr. Maudsley says, "To write as if sanity is a thing of the immaterial, and insanity a thing of the material world, is to infer that men are furnished with brains only that they may become insane." Yet it seems that some physicians find it convenient to entertain both theories; and we are informed in this discourse that Dr. John P. Gray, Superintendent of the State Lunatic Asylum at Utica, in a paper read before the New York State Medical Society, on "The Dependence of Insanity on Physical Disease," takes the ground that mental aberration is due to bodily disorder; but, being "no materialist, he does not regard sound mental action as the result of a sound and healthy brain, and denounces such a notion" as "an attempt to revive the exploded vagaries of the French materialism of the encyclopedists and the Revolution." Obviously the superintendent is a politician as well as a doctor.

But, even assuming that insanity is a bodily disease, Dr. Tourtellot maintains that it is impossible to find the indications of it in the bodily structures. He quotes Leidersdorf as declaring any such demonstration "outside the realm of possibility;" while Griesinger, the celebrated German authority, ridicules the "belief that every mental disorder must correspond to a palpable cerebral lesion." The practical evil of the extreme theory, that insanity is in all cases essentially a bodily disease, Dr. Tourtellot thinks to be an undue reliance upon medication for a cure. This leads to the appeal for legislative aid upon an enormous scale, to provide medical establishments for the treatment of the insane. Upon this point Dr. Tourtellot remarks:

"I must point you to one other evil, of perhaps greater magnitude, which is directly due to Dr. Gray's false theory and vicious reasoning. You are doubtless aware that the demand for new hospital-asylums, to provide for all the insane of the State, has been based mainly upon the doctrine that insanity is a bodily disease, easily curable in its early stages. At length, the Legislature of this State was prevailed upon to authorize the building of two such asylums. And, as they were in the end to save vast sums of money through the speedy cure of those who must otherwise, as incurable, become a public charge for life, it was not necessary to spare expense upon them. These asylums, in fact, were planned to require an outlay of from $8,000,000 to $10,000,000 for a total capacity of 800 patients. Now, I need not stop to prove to you how even more absurd is the plan of 'stamping out' insanity by medical treatment than that of exterminating cancer and scrofula would be. The serious proposal of such a scheme by a medical man in any part of Europe would be enough to brand him as a visionary or a quack. That it should not only have been proposed, but apparently accepted as the basis of a policy of provision for the insane in this country, seems hardly credible. But, as you know, the policy is still urged upon our State Legislatures, and the argument for it is repeated in nearly all our asylum-reports, year after year."

Dr. Gray makes the statement in his last report to the Legislature, that "a recovery of four-fifths" (of insane persons) "might reasonably be expected, if treated within three months of the first attack; while, if twelve months are allowed to elapse, the same proportion may be considered as incurable." Dr. Tourtellot replies that this is a fallacy, and states that, in a large number of the cases, the outbreak is sudden and transient, and that "it is quite certain that four-fifths of such patients will recover even without special treatment. . . . But, on the other hand, patients brought to the asylum a year or more after their attack, are of a wholly different class. Their insanity was chronic, not only in its fully-developed stage, but in the stage of invasion. It was never possible to bring them to an asylum within three months of the date of their attack. Their insanity came on imperceptibly, and opinions might differ months or even years as to the time of its beginning."

In regard to the vexed question of the definition of insanity, the author remarks:

"After what has been said, you will not expect me, in closing, to present you with a definition of insanity as a physical fact. The term is a purely metaphysical one, and cannot be translated into the language of natural science. To say that insanity is morbid energy of the nervous element, is to state what we all admit to be a legitimate scientific hypothesis, but at the same time know to be worthless as a definition. On the other hand, a precise definition from the side of mental science is acknowledged to be impossible. Taken in its broad sense, the word simply denotes a marked degree of mental disorder. What that degree is, depends upon the practical issue presented in each case. In highly-civilized countries a moderate degree only, more or less incapacitating for the due performance of the social relations, constitutes insanity, and entitles its subjects to the charity and protection of the state. Where it is claimed to excuse from the punishment of crime, a high degree of mental disorder is required to be shown. Other degrees are necessary in order to make void a will, or excuse from the performauce of a contract. A slight degree only may constitute a medical case of insanity, of the greatest interest and importance. In a narrower and technical sense, insanity denotes chronic mental disorder not obviously belonging, as a symptom, to some recognized form of bodily disease."

Animal Physiology: The Structure and Functions of the Human Body. By John Cleland, M. D., F. R. S. New York: G. P. Putnam's Sons. 12mo, 325 pages. Price, $1.50.

In the first chapter of this work the author gives a brief account of the relations of physiology to other departments of science; a description of the composition and properties of organic matter; definitions of the principal fuuctions; and a couple of pages on the neucleated corpuscle, which he is disposed to regard as the ultimate physiological unit. Connective tissues; the skeleton and its function, with the minute structure of bones, ligaments, and cartilages; muscles, their structure and mode of action; and the structure and functions of the skin and mucous membrane, form the subjects of the four succeeding chapters. Alimentation, and the apparatus and process of digestion, are next treated; and then follow in the usual order chapters on the blood, the circulation and its organs, and respiration. The structure and functions of the glands are next disposed of; and three chapters are given to the anatomy and physiology of the nervous system, including the organs of special sense. Voice and speech are next treated; and the book closes with a chapter on the subject of reproductiou and development. The matter of the work is largely anatomical, too much so, in our opinion, for a book on physiology; but, as the author says that it is intended for those "previously unacquainted with anatomical details," this feature may be exactly suited to their needs. In this case, however, the physiology should have been similarly graded, which it is not, being much too advanced for pupils ignorant of anatomy. The work is mainly a compilation, the author claiming originality only in his method of grouping the facts. The style is clear, the illustrations are numerous and well executed, and both a glossary and index are appended.

Elements of Zoology for Schools and Science Classes. By M. Harrison. New York: G. P. Putnam's Sons. 16mo, 172 pages. Price, 75 ceuts.

The title of this book is doubly misleading. It is called a zoology, when, in fact, it deals with only one department of that great subject, viz., comparative anatomy; and, instead of giving the *elements* of this, goes rather to the opposite extreme, being little more than a bare statement of those later generalizations embodied in modern systems of classification. The book is not adapted to the wants of beginners, and is, therefore, quite out of place in an "elementary series." Those, however, desiring a brief summary of this branch of zoological science will find it of service, though the works of Huxley, from which it is mainly derived, put the subject in a much more attractive shape. The book is copiously illustrated, has a series of questions attached to each of the chapters, and is provided with a glossary.

MISCELLANY.

Observations of the Transit.—So far as heard from, the numerous expeditions which went out to observe the recent transit of Venus met with a fair measure of success. By the wise liberality of the various governments, the contingencies of fair or foul weather were provided against, and the view, which at one point was obstructed by clouds, was more successfully had at some other station in the same latitude, where the skies were more propitious. At Wladiwostock, the most northern station occupied by American observers, the moment of first contact was accurately ascertained, despite a hazy atmosphere, and 13 photographs were taken. From Peking, which is station 2 in Prof. Langley's charts, we have as yet seen no report. At Nagasaki, the observers met with complete success. At Hobart Town, success was only partial; still 113 photographs were taken. The party whose station, according to Prof. Langley, was Bluff Harbor, New Zealand, seem to have located themselves at Queenstown, in that colony. Their observations were very successful, and "237 photographs were made of the first contact." From the remaining three American stations, viz., Chatham, Kerguelen, and Possession Islands, no report has yet been received.

Accounts from stations occupied by European astronomers report entire success at Cairo, Suez, Thebes (Egypt), Bushire (Persia), Calcutta, Rurkee, Kurrachee (India), Hiogo, Nagasaki, Yokohoma (Japan), Melbourne (Australia), Hawaiian Islands (3), and Tschita and Jalta (Russia). From twelve stations total failure is reported, and from seven partial success. The success of the American party in New Zealand is specially gratifying, as furnishing observations from a distant point in the Southern Hemisphere, to be compared with those taken near the same meridian in the Northern Hemisphere. The observers in the more remote islands of the South Sea (Chatham, Kerguelen, Possession) are not likely to be heard from for some weeks. Arrangements have been made by the British Astronomer-Royal to have dispatches from these islands forwarded at the earliest possible moment.

The zeal of the various governments in equipping expeditions for observing this transit is without parallel. Concerning the part taken in this noble strife by the United States, *Nature* observes as follows: "The United States lead all the other nations in respect both to the amount of money which her Government has contributed, and of the discomfort, not to say dangers, of the stations she has chosen in the southern seas. Posts of importance, which were given up as too hopelessly miserable even for enthusiastic English astronomers, have been occupied by Americans."

Systematic Position of the Brachiopoda.—The *Brachiopoda* is a class of animals peculiar to the sea, and their remains fill the rocks of past ages Their bodies are protected by bivalve shells, which externally bear some resemblance to the shell of *Anomia* and other mollusks; and most of them live attached to the sea-bottom by a sort of fleshy stalk or peduncle. It was formerly believed that all Brachiopoda were so attached; but the genus *Lingula*, first carefully studied in the living state by Prof. Edward S. Morse on the coast of North Carolina, was found by him living free in the sand. He published a brief account of his discoveries in the *American Journal of Science and Arts;* and since then the late Dr. Stolinsky, Director of the Geological Survey of India, has confirmed his work by observing the same peculiarities in the large *Lingula anatina* in the Indian Ocean.

From the beginning, the brachiopods have been unhesitatingly classed with the mollusks—neither Cuvier, Owen, Vogt, Hancock (whose remarkable memoir won for him the gold medal of the Royal Society), Huxley, Davidson, nor others who have written on the subject, having even suggested that they belonged elsewhere. After long and industrious study, Mr. Morse, in 1870, boldly announced, in the *American Naturalist*, his belief that the brachiopods were true annelidan worms, and had not the slightest relation to the mollusks. Of course, such revolutionary views were utterly denied by the conchologists in this and other countries; nevertheless, Morse persisted, and he now has the satisfaction of seeing his discoveries indorsed by many of the leading naturalists of the world. From time to time since 1870 he has published, in the "Proceedings and Memoirs of the Boston Society of Natural History," the results of his studies on the Brachiopoda, and was the first to throw light on the embryology and early stages of certain members of this class. Last year, for the first time, he gave a complete history of one of its forms, from the egg to maturity, illustrating his memoir by two steel plates, containing over one hundred figures. The discoveries there recorded fully vindicated the position he had previously maintained, that the brachiopods were annelids, and not mollusks. Among the many naturalists who have indorsed this radical change in classification, Leidy, Mr. A. Agassiz, Hyatt, Packard, Barnard, Hartt, Tuttle, and Dr. Coues, may be named for this country, and Mr. Darwin, Gegenbaur, Haeckel, and others, abroad. Mr. Morse also pointed out in the above memoir that, twenty years ago, Dr. Steenstrup, of Copenhagen, had entertained the same view respecting their affinities.

Recently, Dr. Kowalevsky, the celebrated Russian naturalist, has published in Moscow a memoir on the embryology of certain Brachiopoda studied in the Mediterranean, in which he not only fully confirms the embryological studies of Prof. Morse, but indorses the latter's view, that the brachiopods are annelids. In a review of Kowalevsky's memoir, published in the last number of the *American Journal of Science and Arts*, Mr. A. Agassiz, after calling attention to the striking manner in which the investigations of this writer confirm the view of Steenstrup and Morse regarding the affinities of Brachiopoda with annelids, goes on to say: "It is not out of place to recall the very ungenerous treatment which Morse received at the hands of many conchologists for the heresies of his paper on the systematic position of the Brachiopoda; and it certainly is a striking proof of the sagacity of Morse to have announced so positively, from the history of the American Brachiopoda, the vermiform affinities of brachiopods, now so conclusively proved by the development of Argiope in Kowalevsky's paper."

A Curious Winter Climate.—Prof. Frankland has communicated to the Paris Academy of Science some curious observations made by him in the Rhetian (Grisons) Alps, and specially in two villages situated at an altitude of 5,412 feet, and much frequented by consumptives. Last December, while the soil was covered with snow, at a temperature of 24° Fahr., Mr. Frankland found the patients spending the whole day out-of-doors, in the sunshine, and wearing the same clothing they usually wore in spring and autumn. On inquiring into the cause of this, Mr. Frankland discovered that a thermometer exposed to the sun's rays showed an atmospheric temperature of from 95° to 104° Fahr., that is to say, summer heat. Providing the air is calm, living in this atmosphere is very beneficial to persons affected with chest-diseases. The author at the same time perceived that this heating of the air takes place immediately on the appearance of the sun above the horizon, and that it continues till sunset. Further, he observed that if a thermometer be placed in an inclosed area, one of the walls being of glass, and the others coated with lamp-black, the inside temperature quickly rises to 221° Fahr.

Elongation of the Trunks of Trees.—Mr. Elias Lewis, Jr., of Brooklyn, recently read a paper before the Natural History section of the Long Island Horticultural Society, giving the results of some observations on this subject. He said: "If a tree-trunk lengthens by any process of interior enlargement, it is quite certain that marks upon its surface, or lateral branches, would be carried upward as growth went on. A branch projecting at a given height from the ground would, later, become more elevated." He cited an instance of an oak-tree near Miller's Place, in Suffolk County, L. I., which is evidently over a century old, from which projects an enormous branch at a height of seven feet from the ground. This branch is thirty feet in length, two-thirds that of the tree, and is just one-half the circumference of the trunk (which is $8\frac{1}{2}$ feet) where it issues. It is nearly horizontal, the inclination, which is *upward*, being very slight. At a distance of four feet from the tree, it rests upon a bowlder of great size, and spreads to a width of five feet; but the branch, in its under side, projects squarely against the face of the rock. The branch then rests on the rock about five feet, and from this point of support rises to its terminus. It is considered entirely certain that the branch began its growth when the tree was very small, and its growth has been contemporaneous with that of the trunk.

The under half of the branch, as remarked, is directly against the face of the rock, and could not have increased in length. The branch issued at about seven feet elevation, and this distance has not been increased, else, at its junction with the trunk, it would have been carried up, which has not occurred. This is believed by Mr. Lewis to be conclusively shown in the position of the branch in respect to the rock, which surely has not changed its position; the weight of the rock, above the surface, being probably thirty tons. It is safe to conclude that the branch in question has rested on the rock, in its present position, at least a hundred years, during which time the trunk of the tree has increased in length fifty feet.

NOTES.

Prof. Marsh reached his home in New Haven, December 12th, after an absence of about two months in the West. The results of his "scientific raid" to the Bad Lands, near the Black Hills, were very satisfactory. Nearly two tons of fossil bones were collected, most of them rare specimens, and many unknown to science. There were several species of gigantic *Brontotheridæ*, nearly as large as elephants. At one place the bones were heaped together in such numbers as to indicate that a herd of the animals had been swept into a lake by a great freshet. The whole collection goes to the Peabody Museum of Yale College. A military escort, provided by General Ord, shared with Prof. Marsh the honors and the perils of the brief but brilliant campaign.

Prof. Simon Newcomb, of the Washington Observatory, has gone to Europe to examine the different kinds of flint and crown glass made for optical purposes by the best manufacturers abroad. His trip is in the interest of the Lick Observatory of California, the trustees of that institution wishing to employ the best maker for the founding of the glass.

It is announced that the *Phylloxera* has made its appearance in Switzerland, and the delegates of the vine-growing cantons are considering the best means of preventing its extension. The volcanic soil around Vesuvius is said to be an antidote to the potato-fungus, and to be of great value in the treatment of *Phylloxera*.

Mr. Joseph Willcox, of the Philadelphia Academy of Sciences, has discovered in North Carolina a number of burial-places where the bodies had been placed with the face up, and covered with a coating of plastic clay. A pile of wood was then placed on top and fired, which consumed the body and baked the clay, which retained the form of the body. This was then lightly covered with earth.

The supposed fossil remains of land-plants, found by Mr. Lesquereux in the upper portion of the Cincinnati group (Lower Silurian Rocks), near Lebanon, Ohio, are described by Prof. J. S. Newberry, in *Silliman's Journal*. These fossils are to be referred, according to Mr. Lesquereux, to the *Sigillariæ*, but Prof. Newberry shows that they do not possess the characters which belong to land-plants, and that in all probability they are nothing but casts of the stems of fucoids.

Prof. Alfred M. Mayer, of the Stevens Institute, has shown, by a series of new and very ingenious experiments, the truth of Prof. Henry's inference that the discharge of a Leyden jar is multiple and oscillatory in its nature. Other physicists had already established this point, but it remained for Prof. Mayer to trace the oscillations and to determine the number of partial discharges per second. In one of his experiments he found the average interval between the partial discharges to be $\frac{1}{9900}$ of a second.

A tunnel, very nearly one mile in length, has been bored through Musconetcong Mountain, N. J., on the line of the Easton & Perth Amboy Railroad. With the exception of the Hoosac, this is the longest tunnel east of the Mississippi. The engineering-work on this tunnel was singularly accurate, the error in line being only half an inch, in levels one-fifth of an inch, in chaining or measurement six inches.

The climate of Minnesota has been recommended as very favorable to consumptives, on the ground that the air of that region is exceptionally dry. But, from the *Monthly Weather Review* of the Signal-Office, for November last, it appears that Minnesota shows the greatest relative humidity of all the regions there named. Thus, the relative humidity for New England was .69, middle Atlantic States .66, lake region .69, Minnesota .77.

The Caen Academy of Science offers a prize of 4,000 francs for the best essay on the "Function of Leaves in the Vegetation of Plants." The Academy does not want simply an exposition of the present state of science upon this question, but also exact experiments, performed by the competitors themselves, and new facts tending to throw light upon the present theories. The essays to be submitted before January 1, 1876.

Prof. Landois reports to the Natural History Society of Prussian Rhineland that ants have the power of producing vocal sounds, though of a pitch inaudible to man. He has proved that they possess a sound-apparatus resembling that belonging to the sand-wasp.

DR. HENRY MAUDSLEY.

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THE GENESIS OF SUPERSTITIONS.[1]

By HERBERT SPENCER.

COMPREHENSION of the thoughts generated in the primitive man by his converse with the surrounding world can be had only by looking at the surrounding world from his stand-point. The accumulated knowledge and the mental habits slowly acquired during education must be suppressed, and we must divest ourselves of conceptions which, partly by inheritance and partly by individual culture, have been rendered necessary. None can do this completely, and few can do it even partially.

It needs but to observe what unfit methods are adopted by educators, to be convinced that even among the disciplined the power to frame thoughts which are widely unlike their own is extremely small. When we see the juvenile mind plied with generalities while it has yet none of the concrete facts to which they refer—when we see mathematics introduced under the purely rational form, instead of under that empirical form with which it should be commenced by the child, as it was commenced by the race—when we see a subject so abstract as grammar put among the first instead of among the last, and see it taught analytically instead of synthetically; we have ample evidence of the prevailing inability to conceive the ideas of undeveloped minds. And, if, though they have been children themselves, men find it hard to rethink the thoughts of the child, still harder must they find it to rethink the thoughts of the savage. To keep out automorphic interpretations is beyond our power. To look at things with the eyes of absolute ignorance, and observe how their attributes and actions originally grouped themselves in the mind, imply a self-suppression that is impracticable.

Nevertheless, we must here do our best to conceive the surrounding world as it appeared to the primitive man, that we may be able

[1] From author's advance sheets of the "Principles of Sociology," Part II., chapter viii. "Primitive Ideas."

the better to interpret deductively the evidence available for induction. And, though we are incapable of reaching the conception by a direct process, we may make some approach to it by an indirect process. Guided by the doctrine of evolution in general, and by the more special doctrine of mental evolution, we may help ourselves to delineate primitive ideas in some of their leading traits. Having observed *a priori* what must be the characters of those ideas, we shall be as far as possible prepared to realize them in imagination, and then to discern them as actually existing.

We must set out with the postulate that primitive ideas are natural, and, under the conditions in which they occur, rational. In early life we have been taught that human nature is everywhere the same. Led thus to contemplate the beliefs of savages as beliefs entertained by minds like our own, we marvel at their strangeness, and ascribe perversity to those who hold them. Casting aside this error, we must substitute for it the truth that the laws of thought are everywhere the same, and that, given the data as known to him, the inference drawn by the primitive man is the reasonable inference.

In the sky, clear a few moments ago, the savage sees a fragment of cloud which grows while he gazes. At another time, watching one of these moving masses, he observes shreds of it drift away and vanish; and presently the whole disappears. What thought results in him? He knows nothing about precipitation and dissolution of vapor, nor has there been any one to stop his inquiry by the reply, "It is only a cloud." The essential fact forced on his attention is that something he could not before see has become visible, and something just now visible has vanished. The whence, and the where, and the why, he cannot tell; but there is the fact.

In this same space above him occur other changes. As day declines, bright points here and there show themselves, becoming clearer and more numerous as darkness increases, and then at dawn they fade gradually, until not one is left. Differing from clouds utterly in size, form, color, etc., differing also as continually reappearing in something like the same places, in the same relative positions, and in moving but very slowly always in the same way, they are yet like them in becoming now visible and now invisible. That feeble lights may be wholly obscured by a bright light, and that the stars are shining during the day though he does not see them, are facts beyond the imagination of the savage. The truth, as he perceives it, is that these existences now show themselves and now are hidden.

Differing greatly from clouds and stars in their behavior as the sun and moon do, they show, in common with them, this same alternation of visibility with invisibility. The sun rises on the other side of the mountains; from time to time going behind a cloud, presently comes out again; and at length hides below the level of the sea. The moon, besides doing the like, first increases slowly night after night, and then wanes, by-and-by reappearing as a thin bright streak, with the rest of her disk so faintly perceptible as to seem only half existing.

Added to these commonest and most regular occultations and manifestations, are various others, even more striking—comets, meteors, and the aurora with its arch and pulsating streams; flashes of lightning, rainbows, halos. Differing from the rest and from one another as these do, they similarly appear and disappear. So that by a being absolutely ignorant, but able to remember, and to group the things he remembers, the heavens must be regarded as a scene of arrivals and departures of many kinds of existences; some gradual, some sudden, but alike in this, that it is impossible to say whence the existences come or whither they go.

Not the sky only, but also the earth's surface, supplies various instances of these disappearances of things which have unaccountably appeared. Now the savage sees little pools of water formed by the rain-drops coming from a source he cannot reach; and now, in a few hours, the gathered liquid has made itself invisible. Here, again, is a fog; perhaps lying isolated in the hollows, perhaps enwrapping every thing, which came a while since and presently goes without leaving a trace of its whereabouts. Afar off is perceived water—obviously a great lake; but on approaching it the seeming lake recedes, and cannot be found. In the desert, what we know as sand-whirlwinds, and on the sea what we know as water-spouts, are to the primitive man moving things which appear and then vanish. Looking out over the ocean, he recognizes an island known to be a long way off, and commonly invisible, but which has now risen out of the water; and to-morrow, just above the horizon, he observes an inverted figure of a boat, perhaps by itself, or perhaps joined to an erect figure above. In one place he sometimes perceives land-objects on the surface of the sea, or in the air over it—*a fata morgana;* and in another, over against him on the mist, there occasionally comes into view a gigantic duplicate of himself—"a Brocken spectre." These occurrences, some familiar and some unfamiliar, repeat the same experience—show transitions between the visible and the invisible.

Once more, let us ask what must be the original conception of wind. Consider the facts apart from hypothesis, and the implication which every breeze or gust carries with it is that of a power neither visible nor tangible. Nothing in early experiences yields the idea of air, as we are now familiar with it; and, indeed, probably most can recall the difficulty they once had in thinking of the surrounding medium as a material substance. The primitive man cannot regard it as a something which acts as do the things he sees and handles. Into this seemingly-empty space around, there from time to time comes an invisible agent which bends the trees, drives along the leaves, disturbs the water, and which he feels moving his hair, fanning his cheek, and now and then pushing his body with a force he has some difficulty in overcoming. What may be the nature of this agent there is nothing to tell him; but one thing is irresistibly thrust on his consciousness —that sounds can be made, things about him can be moved, and he himself can be buffeted, by an existence he can neither grasp nor see.

What primitive ideas arise out of these experiences derived from the inorganic world? In the absence of hypothesis (which is foreign to thought in its earliest stages), what mental association do these multitudinous occurrences, some at long intervals, some daily, some hourly, some from minute to minute, tend to establish? They present, under many forms, the relation between a perceptible and an imperceptible mode of existence. In what way does the savage think of this relation? He cannot think of it in terms of dissipation into vapor and condensation from it, nor in terms of optical relations producing illusions, nor in any terms of physical science. How, then, does he formulate it? A clew to the answer will be furnished by recalling certain remarks of young children. When an image from the magic lantern, thrown on a screen, suddenly disappears on withdrawal of the slide, or when the reflection from a looking-glass, cast for a child's amusement on the wall or ceiling, is made to vanish by changing the attitude of the glass, the child asks, "Where is it gone to?" The notion arising in its mind is, not that this something no longer seen has become non-existent, but that it has become non-apparent; and it is led to think this by daily observing persons disappear behind adjacent objects, by seeing things put away out of sight, and by now and again finding a toy that had been hidden or lost. Similarly, the primitive idea is, that these various existences now manifest themselves and now conceal themselves. As the animal which he has wounded hides itself in the brushwood, and, if it cannot be found, is supposed by the savage to have escaped in some incomprehensible way, but to be still existing, so, in the absence of accumulated and organized knowledge, the implication of all these experiences is that many of the things above and around pass often from visibility to invisibility, and conversely. Bearing in mind how the actions of wind prove that there is an invisible form of existence which manifests power, we shall see this belief to be plausible.

It remains only to be pointed out that along with this conception of a visible condition and an invisible condition, which each of these many things has, there comes the conception of duality. Each of them is in a sense double, since it has these two complementary modes of being.

Significant facts of another order, from time to time disclosed, may next be noted—facts irresistibly impressing the primitive man with the belief that things are transmutable from one kind of substance to another. I refer to the facts forced on his attention by embedded remains of animals and plants.

While gathering food on the sea-shore, he finds, protruding from a rock, a shell which, if not of the same shape as the shells he picks up, is so similar that he naturally classes it with them. But, instead of being loose, it is part of a solid block; and, on breaking it off, he finds its inside as hard as its matrix. Here, then, are two kindred forms, one of which consists of shell and flesh, and the other of shell and stone. Near at hand, in the mass of clay *débris* detached from the adjacent cliff, he picks up a fossile ammonite. Perhaps, like the *Gryphœa* just examined, it has a shelly coating with a stony inside. Perhaps, as happens with some liassic ammonites of which the shell has been dissolved away, leaving the masses of indurated clay that filled its chambers locked loosely together, it suggests a series of articulated vertebræ coiled up; or, as with other liassic ammonites of which the shell has been replaced by iron pyrites, it has a glistening appearance like that of a snake's skin. As such fossils are sometimes called "snake-stones," and are in Ireland supposed to be the serpents St. Patrick banished, we cannot wonder if the uncritical savage, classing this object with those it most resembles, thinks it a transmuted snake—once flesh and now stone. In another place, where a gully has been cut through sandstone by a stream, he observes on the surface of a slab the outline of a fish, and, looking closely, sees scales and the traces of fins; and elsewhere, similarly embedded in rock, he finds skulls and bones not unlike those of the animals he kills for food; some of them, indeed, not unlike those of men.

Still more striking are the transmutations of plants occasionally discovered. I do not refer so much to the prints of leaves in shale, and the fossil stems found in strata accompanying coal; I refer, more especially, to the silicified trees here and there met with. Retaining, not their general forms only but their minute structures, so that the annual growths are marked by rings of color such as mark them in living stems, these yield the savage clear evidence of transmutation. With all our knowledge it remains difficult to understand how silica can so replace the components of the wood as to preserve the appearance thus perfectly; and for the primitive man, knowing nothing of molecular action and unable to conceive a process of substitution, there is no possible thought but that the wood is changed into stone.

Thus, if we ignore those conceptions of physical causation which have arisen only as experiences have been slowly organized during civilization, we shall see that in their absence there would be nothing to prevent us from putting on these facts the interpretations which the primitive man puts on them. Looking at the evidence through his eyes, we find his belief, that things change from one kind of substance to another, to be the inevitable belief.

And here let us not omit to note that along with the notion of transmutation is involved the notion of duality. These things have obviously two states of existence.

Much evidence forces on the primitive man the notion that things can change their forms as well as their substances. Did we not thoughtlessly assume that truths which culture has made obvious to us are naturally obvious, we should see that an unlimited belief in metamorphosis is one which the savage cannot avoid. From early childhood we hear remarks implying that certain transformations which living things undergo are matters of course, while other transformations are impossible. This distinction we suppose to have been manifest at the outset. But, at the outset, the observed metamorphoses suggest that any metamorphosis may occur.

Consider the immense contrast in form as in substance between the seed and the plant. Look at this nut with hard brown shell and white kernel, and ask what basis there is for the expectation that from it will presently come a soft shoot and green leaves. When young we are told that the one *grows* into the other; and, the blank form of explanation being thus filled up, we cease to wonder and inquire. Yet, it needs but to consider what thought would have arisen had there been no one to give this mere verbal solution, to see that the thought would have been—transformation. Apart from hypothesis, the bare fact is that a thing having one size, shape, and color, becomes a thing having an utterly different size, shape, and color.

Similarly with the eggs of birds. But a few days since this nest contained four or five rounded, smooth, speckled bodies; and now in place of them are as many chicks gaping for food. We are brought up to the idea that the eggs have been *hatched;* and with this semblance of interpretation we are content. This extreme change in visible and tangible characters being recognized as one constantly occurring in the order of Nature, is therefore regarded as not remarkable. But to a mind occupied by no generalized experiences of its own or of others, there would seem nothing more strange in the production of chicks from nuts than in the production of chicks from eggs: a metamorphosis of the kind we think impossible would stand on the same footing as one which familiarity has made us think natural. Indeed, on remembering that there still survives, or till lately survived, the popular belief that barnacle-geese arise from barnacles—on learning that, even in the early transactions of the Royal Society, there is a paper describing a barnacle as showing faint traces of the young bird it is about to produce—it will be seen that only by advanced science has there been discriminated the natural organic transformations, from transformations which to ignorance seem just as likely.

The insect-world yields instances of metamorphoses even more misleading. To a branch which shades the opening of his wigwam, the savage saw, a few days ago, a caterpillar hanging with its head downward. Now in the same place hangs a differently formed and colored thing—a chrysalis. In a week or two after there comes out a butterfly: leaving a thin, empty case. These insect-metamorphoses, as we call them, which we now interpret as processes of evolution presenting certain definitely-marked stages, are, in the eyes of the primitive man, metamorphoses in the original sense. He accepts them as actual changes of one thing into another thing utterly different.

How readily the savage confounds these metamorphoses which really occur with metamorphoses apparently like them but impossible, we shall perceive on considering a few cases of mimicry by insects, and the conclusions they lead to. Many caterpillars, beetles, moths, butterflies, simulate the objects by which they are commonly surrounded. The *Onychocerus scorpio* is so exactly like, "in color and rugosity," to a piece of the bark of the particular tree it frequents, "that until it moves it is absolutely invisible:" thus raising the idea that a piece of the bark itself has become alive. Another beetle, *Onthophilus sulcatus*, is "like the seed of an umbelliferous plant;" another "undistinguishable by the eye from the dung of caterpillars;" some of the *Cassidæ* "resemble glittering dew-drops upon the leaves;" and there is a weevil so colored and formed that, on rolling itself up, it "becomes a mere oval brownish lump, which it is hopeless to look for among the similarly-colored little stones and earth pellets among which it lies motionless," and out of which it emerges after its fright, as though a pebble had become animated. To these examples given by Mr. Wallace, may be added that of the "walking-stick insects," so called "from their singular resemblance to twigs and branches."

"Some of these are a foot long and as thick as one's finger, and their whole coloring, form, rugosity, and the arrangement of the head, legs, and antennæ, are such as to render them absolutely identical in appearace with dead sticks. They hang loosely about shrubs in the forest, and have the extraordinary habit of stretching out their legs unsymmetrically, so as to render the deception more complete."

What wonderful resemblances exist, and what illusions they may lead to, will be fully perceived by those who have seen, in Mr. Wallace's collection of butterflies, the Indian genus *Kallima*, placed amid the objects it simulates. Habitually settling on branches bearing dead leaves, and closing its wings, it then resembles a dead leaf, not only in general shape, color, markings, but in so seating itself that the processes of the lower wings unite to form the representation of a foot-stalk. When it takes flight, the impression produced is that one of the leaves has changed into a butterfly. This impression is greatly strengthened when the creature is caught. On the under side of the closed wings is still clearly marked the midrib, running right across them from foot-stalk to apex; and here, too, are lateral veins. Nay, this is not all. Mr. Wallace says:

"We find representations of leaves in every stage of decay, variously blotched and mildewed and pierced with holes, and in many cases irregularly covered with powdery black dots gathered into patches and spots, so closely resembling the various kinds of minute fungi that grow on dead leaves that it is impossible to avoid thinking at first sight that the butterflies themselves have been attacked by real fungi."

On recalling the fact that, a few generations ago, all civilized people believed, as many civilized people believe still, that decaying meat is itself transformed into maggots, on being reminded that among our peasantry, at the present time, the thread-like aquatic worm *Gordius* is said to be horse-hair that has fallen into the water and become living, we shall see it to be inevitable that these extreme resemblances should suggest the notion of actual metamorphoses. That this notion, so suggested, becomes a belief, is a proved fact. In Java and neighboring regions inhabited by it, that marvelous insect, "the walking leaf," is positively asserted to be a leaf that has become animated. What else should it be? In the absence of that explanation of mimicry so happily hit upon by Mr. Bates, no natural origin for such wonderful likenesses between things wholly unallied can be imagined. And, while there is no generalized knowledge, there is nothing to prevent acceptance of these apparent transformations as real transformations; indeed, apparent and real are not distinguished until criticism and skepticism have made some progress.

Once established, the belief in transformation extends itself without resistance to other classes of things. Between an egg and a young bird, there is a far greater contrast in appearance and structure than between one mammal and another. The tadpole, with a tail and no limbs, differs from a young frog with four limbs and no tail, more than a man differs from a hyena; for both of these have four limbs, and both laugh. Evidently, then, the natural metamorphoses so abundant throughout Nature, joined with these apparent metamorphoses which the primitive man inevitably confounds with them, originate the conception of metamorphoses in general, which rises into an explanation everywhere employed without check.

Here, again, we have to note that, while initiating and fostering the notion that things of all kinds may suddenly change their forms, the experiences of transformation confirm the notion of duality. Each object is not only what it seems, but is potentially something else.

What is a shadow? Familiar as mature life has made us with shadows, and almost automatic as has become the interpretation of them in terms of physical causation, we do not ask how they look to the absolutely ignorant.

Those, from whose minds the thoughts of childhood have not wholly vanished, will remember the interest they once felt in watching their shadows—moving legs and arms and fingers, and observing how corresponding parts of the shadows moved. By a child a shadow is thought of as an entity. I do not assert this without evidence. A memorandum made in 1858, in elucidation of the ideas described in the just-published book of Williams on the Feejeeans, concerns a little girl of some seven, who did not know what a shadow was, and to whom I could give no conception of its true nature.

On ignoring acquired ideas, we shall see this difficulty to be quite natural. A thing having outlines, and differing from surrounding things in color, and especially a thing which moves, is, in other cases, a reality. Why is not this a reality? The conception of it, merely a negation of light, is a conception not to be framed until after the behavior of light is in some degree understood. It is true that the uncultured among ourselves, without clearly formulating the truth that light, proceeding in straight lines, necessarily leaves unlighted spaces behind opaque objects, nevertheless come to regard a shadow as naturally attending an object exposed to light, and as not being any thing real. But this is one of the countless cases in which inquiry is set at rest by a verbal explanation. "It's only a shadow," is the answer given in early days; and this answer, repeatedly given, deadens wonder and stops further thought.

But the primitive man, with no one to answer his questions, and without ideas of physical causation, necessarily concludes a shadow to be an actual existence, which belongs in some way to the person casting it. He simply accepts the facts. Whenever the sun or moon is visible, he sees this attendant thing which rudely resembles him in shape, which moves when he moves, which now goes before him, now keeps by his side, now follows him, which lengthens and shortens as the ground inclines this way or that, and which distorts itself in strange ways as he passes by irregular surfaces. True he cannot see it in cloudy weather; but, in the absence of a physical interpretation, this simply proves that his attendant something comes out only on bright days and bright nights. It is true, also, that such resemblance as his shadow bears to him, and its approximate separateness from him, are shown only when he stands up: on crouching, it becomes indefinitely formed; and as he lies down it seems to disappear and partially merge into him. But this observation confirms his impression of its reality. This greater or less separateness of his own shadow reminds him of cases where a shadow is quite separate. When watching a fish in the water on a fine day, he sees a dark, fish-shaped patch on the bottom at a considerable distance from the fish, but nevertheless following it hither and thither. Lifting up his eyes, he observes dark patches moving along the mountain-sides—patches which, whether traced or not to the clouds that cast them, are seen to be widely disconnected from objects. These facts show him that shadows, often so closely joined with their objects as to be hardly distinguishable from them, may become distinct and remote.

Thus, by minds beginning to generalize, shadows must be conceived as existences appended to, but capable of separation from, material things. And that they are so conceived is abundantly proved. We find it stated by Bastian of the Benin negroes, that they regard men's shadows as their souls; and he also says of the Wanika that they are afraid of their own shadows: possibly thinking, as some other negroes do, that their shadows watch all their actions, and bear witness against them. Among the Greenlanders, according to Crantz, a man's shadow is one of his two souls—the one which goes away from his body at night. Among the Feejeeans, too, the shadow is called "the dark spirit," as distinguished from another which each man possesses. And the community of meaning, hereafter to be noted more fully, which various unallied languages betray between shade and spirit, shows us the same thing.

These illustrations of the truth that a shadow is originally regarded as an appended entity suggest more than I here wish to show. The ideas of the uncivilized, as we now find them, have developed from their first vague forms into forms having more coherence and definiteness. We must neglect the special characters of these ideas, and consider only that most general character with which they began. This proves to be the character we inferred above. Shadows are realities which, always intangible and often invisible, nevertheless severally belong to their visible and tangible correlatives; and the facts they present furnish further materials both for the notion of apparent and unapparent states, and for the notion of a duality in things.

Other phenomena, in some respects allied, yield these notions still more materials. I refer to reflections.

If the rude resemblance in outlines and movements which a shadow bears to the person casting it raises the idea of a second entity, much more must the exact resemblance of a reflection do this. Repeating all the details of form, of light and shade, of color, and mimicking even the grimaces of the original, this image cannot at first be interpreted otherwise than as an existence. Only by experiment is it ascertained that to the visual impressions there are not, in this case, those corresponding tactual impressions yielded by most other things. What results? Simply the notion of an existence which can be seen but not felt. Optical interpretation is impossible. That the image is formed by reflected rays, cannot be conceived while physical knowledge does not exist; and, in the absence of authoritative statement that the reflection is a mere appearance, it is inevitably taken for a reality—a reality in some way belonging to the person whose traits it simulates and whose actions it mocks.

Moreover, these duplicates seen in the water yield to the primitive man obvious verifications of certain other beliefs which surrounding things suggest. Deep down in the clear pool, are there not clouds like those he sees above? The clouds above appear and disappear. Has not the existence of these clouds below something to do with it? At night, again, seeming as though far underneath the surface of the water, are stars as bright as those overhead. Are there, then, two places for the stars? and did those which disappeared during the day go below where the rest are? Once more, overhanging the pool is this dead tree, from which he breaks off branches for firewood. Is there not an image of it too? and the branch which he burns and which vanishes into nothing in burning—is there not some connection between its invisible state and that image of it in the water which he could not touch, any more than he can now touch the consumed branch?

That reflections thus generate a belief—confused and inconsistent it may be, but still a belief—that each individual has a duplicate, usually unseen, but which may be seen on going to the water-side and looking in, is not an *a priori* inference only; there are facts verifying it. According to Williams, some Feejeeans "speak of man as having two spirits. His shadow is called 'the dark spirit,' which, they say, goes to Hades. The other is his likeness reflected in water or a looking-glass, and is supposed to stay near the place in which a man dies." This belief in two spirits is, indeed, the most consistent one. For are not a man's shadow and his reflection separate? and are they not co-existent with one another and with himself? Can he not, standing at the water-side, observe that the reflection in the water and the shadow on the shore, simultaneously move as he moves? Clearly, while both belong to him, the two are independent of him and of one another; for both may be absent together, and either may be present in the absence of the other.

Early theories about this duplicate are now beside the question, and must be ignored. We are concerned only with the fact that it is thought of as real. To the primitive mind, making first steps in the interpretation of the surrounding world, here is revealed another class of facts confirming the notion that existences have their visible and invisible states, and strengthening the implication of a duality in each existence.

Let any one ask himself what would be his thought if, in a state of childlike ignorance, he were to pass some spot and to hear repeated a shout which he uttered. Would he not inevitably conclude that the answering shout came from another person? Succeeding shouts severally repeated with words and tones like his own, yet without visible source, would rouse the idea that this person was mocking him, and at the same time concealing himself. A futile search in the wood or under the cliff would end in the conviction that the hiding person was very cunning: especially when joined to the fact that here, in the spot whence the answer before came, no answer was now given—obviously because it would disclose the mocker's whereabouts. If at this same place, on subsequent occasions, this responsive shout from a source eluding search always came to any passer-by who called out, the resulting thought would be that in this place there dwelt one of these invisible forms—a man who had passed into an invisible state, or who could become invisible when sought.

Nothing approaching to the physical explanation of an echo can be framed by the uncivilized man. What does he know about the reflection of sound-waves?—what, indeed, is known about the reflection of sound-waves by the mass of our own people? Were it not that the spread of knowledge has modified the mode of thought throughout all classes, producing everywhere a readiness to accept what we call natural interpretations, and to assume that there are natural interpretations to occurrences not comprehended, there would even now be an explanation of echoes as caused by unseen beings.

That to the primitive mind they thus present themselves is shown by facts. Southey, writing of the Abipones, says that "what became of the Lokal" (spirit of the dead) "they knew not, but they fear it, and believe that the echo was its voice." Concerning the Indians of Cumana (Central America), Herrera tells us that they "believed the soul to be immortal, that it did eat and drink in a plain where it resided, and that the echo was its answer to him that spoke or called." And, narrating his voyage down the Niger, Lander says that "from time to time, as we came to a turn in the creek, the captain of the canoe halloed to the fetich, and, where an echo was returned, half a glass of rum and a piece of yam and fish were thrown into the water. When asked why, he said, 'Did you not hear the fetich?'"

Here, as before, I must ask the reader to ignore these special interpretations, acceptance of which forestalls the argument. Attention is now drawn to this evidence simply as confirming the inference that, in the absence of physical explanation, an echo is conceived as the voice of some one who avoids being seen. So that once more we have duality implied—of an invisible as well as a visible state.

To a mind unfurnished with any ideas save those of its own gathering, surrounding Nature thus presents multitudinous cases of seemingly-arbitrary change—now slight and slow, now gradual and great, now sudden and extreme. In the sky and on the earth, things make their appearance and disappear; and there is nothing to show why they do so. Here on the surface and there deeply embedded in the ground are things that have been transmuted in substance—changed from flesh to stone, from wood to flint. Living bodies on all sides exemplify metamorphosis in ways marvelous enough to the instructed, and to the primitive man quite incomprehensible. And this protean character which so many things around him exhibit, and which familiarize him with the notion that there are two or more interchangeable states of existence, is again impressed on him by such phenomena as shadows, reflections, and echoes.

Did we not thoughtlessly accept as innate the conceptions slowly elaborated during civilization and acquired insensibly during our early days, we should at once see that these ideas which the primitive man forms are inevitably formed. The laws of mental association necessitate these primitive notions of transmutation, of metamorphosis, of duality; and, until experiences have been systematized, no limits or restraints are known. With the eyes of developed knowledge we look at the snow as a particular form of crystallized water, and at hail as drops of rain which congealed as they fell. When these become fluid we say they have thawed—thinking of the change as a physical effect of heat; and, similarly, when the hoar-frost fringing the sprays turns into hanging drops, or when the surface of the pool solidifies and again liquefies. But, looked at with the eyes of absolute ignorance, these are transmutations of substance—passings from one kind of existence into another kind of existence. And in like ways are necessarily conceived all the changes above enumerated.

Let us now ask what happens in the primitive mind when there has been accumulated this heterogeneous assemblage of crude ideas, having, amid their differences, certain resemblances. In conformity with the law of evolution, every aggregate tends to integrate, and to differentiate while it integrates. The aggregate of primitive ideas must do this. After what manner will it do it? At the outset, these multitudinous vague notions form a loose mass without order. They slowly segregate, like cohering with like, and so forming indefinitely-marked groups. When these groups begin to form a consolidated whole, constituting a general conception of the way in which things at large go on, they must do it in the same way: such coherence of the groups as arises must be due to some likeness among the members of all the groups. We have seen that there is such a likeness—this common trait of duality joined with this aptitude for passing from one mode of existence to another.

Integration must commence by the recognition of some conspicuous typical case. It is a truth perpetually illustrated, that accumulated facts lying in disorder begin to assume some order if an hypothesis is thrown among them. When into a chaos of detached observations is introduced an observation akin to them in which a causal relation is discernible, it forthwith commences assimilating to itself from this heap of observations those which are congruous, and tends even to coerce into union those of which the congruity is not manifest. One may say that as the protoplasm forming an unfertilized germ remains inert until the matter of a sperm-cell is joined with it, but begins to organize when this addition is made, so a loose aggregate of observations continues unsystematized in the absence of an hypothesis, but under the stimulus of an hypothesis undergoes changes bringing about a coherent systematic doctrine. What particular example, then, of this prevalent duality plays the part of an organizing principle to the aggregate of primitive ideas? We must not look for an hypothesis properly so called: an hypothesis is an implement of inquiry not to be framed by the primitive mind. We must look for some experience in which this duality is forcibly thrust on the attention. As a consciously-held hypothesis is habitually based on some obtrusive instance of a relation, which other instances are suspected to be like, so the particular primitive notion which is to serve as an unconscious hypothesis, setting up organization in this aggregate of primitive notions, must be one conspicuously exemplifying their common trait.

First identifying this typical notion, we shall afterward have to enter on a survey of the general conceptions which result. It will be needful to pursue various lines of inquiry and exposition not manifestly relevant to our subject; and it will also be needful to consider the meaning of much evidence furnished by men who have advanced beyond the savage state. But this discursive treatment is unavoidable. Until we can figure to ourselves with approximate truth the primitive system of thought, we cannot fully understand primitive conduct; and, rightly to conceive the primitive system of thought, we must compare the systems found in many societies, helping ourselves, by observing its developed forms, to verify our conclusions respecting its undeveloped form.

CHAMELEONS—THEIR HABITS AND COLOR-CHANGES.

By J. FITZGERALD, A. M.

IN consequence of the incredible stories anciently told of the chameleon, one is hardly disposed to regard that animal as a reality; it appears to find its proper place in mythology rather than in natural history—among fabled dragons, centaurs, and griffins, rather than among the actualities of the animal kingdom. The chameleon, however, has a real existence; and, after fiction and fable are brushed aside, a very curious creature indeed remains. It belongs to the Saurian order (lizards). The genus *Chamæleo* embraces about twenty species, none of them American. With one exception, the *common chameleon*, which is naturalized in Southern Spain and in Sicily, these animals are found only in the warmer parts of Africa and Asia. The chameleon is from ten to fifteen inches in length, whereof one-half is represented by the prehensile tail. The body is roughly pyramidal in shape; the skin is covered with papillous elevations instead of scales, and these, in some of the species, assume the shape of spiny processes along the ridge of the back and the median line of the chest and belly. The toes, five in number, are divided into two opposable sets of two and three, the toes of each set being webbed down to the claws, which are long and sharp. The head is angular, rising into a pyramidal occiput. The eyeball is very large, protruding, covered with a single lid, which has a minute aperture in the centre for the very small pupil. There is no external ear. The tongue is extensible to the length of half the total length of the animal, that is, from five to seven inches. The lungs are large, and connect with air-cells underlying the skin. The neck is so short as to prevent the head being turned from side to side. Though the chameleon is arboreal in

CHAMELEON—TONGUE OF CHAMELEON.

its habits, it is very slow in its movements. It is unprovided with any weapons of defense against its enemies. The female lays about thirty eggs, which are deposited in a hollow in the ground, and covered with loose earth.

The immobility of the chameleon distinguishes it markedly from the rest of the lizard tribe, which are generally active and quick in their movements. Alfred Brehm, who received as a present from the African explorer, Schweinfurth, a number of these animals, states that the chameleon never moves at all except from necessity; it will remain in one position on a branch or twig for hours at a time, firmly grasping with tail and paws the object on which it is perched. The eyes, on the contrary, are nearly always in motion. The chameleons sent to Brehm reached their destination in indifferent condition, the skin dry and flabby, and the animals utterly apathetic. Water having been showered upon them in fine spray, they began to recover, and to lick the drops from one another's backs; their skin assumed a better color, and soon they were clambering up and down the branches which stood in their cage, and even engaging in combat. In their battles they use their teeth, but without doing serious injury; and they have a curious way of solemnly lashing one another with their tails. But such activity as this is exceptional in the chameleon: it is to be seen especially in the pairing season. When preying on winged insects, the chameleon is seen occasionally to protrude the knobbed end of his tongue, and in an instant that member is shot forth and again retracted, bearing the prey into the captor's mouth. The extremity of the tongue exudes a sticky substance on which the prey is caught. When flies and other winged insects are not to be had, the chameleon's swivel-eyes scan the trunk of the tree, and the branches above, below, and on all sides around, to see if any creeping thing may be caught. If any such creature is approaching the spot where the chameleon is lying, he waits till it comes within striking distance, and then "discharges" his tongue at it. But, if the creature is traveling away from him, he pursues, though with grave deliberation. If the prey comes very near to his muzzle, the chameleon retreats a little, to increase the distance, and then darts out his tongue. In performing this act, the chameleon displays very great activity; otherwise, all his movements are the reverse of precipitate. Thus, if he would change from his normal position of absolute quietude—his belly resting on an horizontal branch, which he grasps as firmly as he can with all five hands (for his tail is a fifth hand)—he first advances one of the fore-paws one step; then the tail is relaxed, advanced an equal distance, and again coiled tight; next the other feet are advanced a step, one after another; and so on. It is not easy to recognize the propriety of the name *little lion* (*chamœelon*) given to this reptilian tardigrade by the ancient Greeks. And the animal is as harmless as it is slow of movement, though the ancients supposed that in the dog-days it assumes some of the lion's ferocity.

The large, projecting eyeballs of the chameleon are capable of a great variety of movements; and, what is very curious, each of them may, and usually does, act independently of the other. This circumstance compensates for the fixedness of the head, enabling the animal to direct its glances on all sides, without the necessity of calling into play any muscles save those of the eyeball. Still, when about to strike, the chameleon brings both of its eyes to bear upon the object. "Notwithstanding," says Weissenbaum, "the strictly symmetrical construction of the chameleon as to its two halves, the eyes move independently of each other, and convey different impressions to the different centres of perception: the consequence is that, when the animal is agitated, its movements appear like those of two animals glued together. Each half wishes to move its own way, and there is no concert of action. The chameleon, therefore, is not able to swim like other animals; it is so frightened when put into water that the faculty of concentration is lost, and it tumbles about as if in a state of intoxication. Nay, more, the chameleon may be asleep on one side and awake on the other."

The chameleon is often seen to inhale air, gulp after gulp, with great avidity, thus inflating its body enormously, even to the feet and tail. As has been already stated, the animal's lungs are very large—so large, indeed, that it was supposed by Pliny (who simply transcribes the accounts given by Greek authors) that the lungs almost filled the entire cavity of the body; these lungs connect with the air-cells beneath the skin. By taking air into the lungs, whence it passes into the air-cells, the chameleon is able to inflate itself to as much as twice its ordinary size; and often it remains so inflated for a long time, now slightly collapsing, again swelling out, till the skin becomes as tense as the head of a drum. No doubt it was this power of self-inflation which led the ancients to suppose that, "alone among animals, the chameleon neither eats nor drinks, its only sustenance being air."—(*Pliny.*)

But the color-changes of the chameleon form perhaps the most interesting phenomenon connected with this animal. We need not repeat the fabulous stories told about these color-changes: the facts which can be strictly verified by direct observation are wonderful enough without the adornments of imagination. These changes of color range from whity-yellow, through yellow, bright and dark green, to dull black; and these diversities of coloration may affect the entire surface of the animal, or one or other of its sides, or may appear only in spots. When the chameleon is asleep, and not exposed to the direct rays of the sun, its color is a whity-yellow; when basking in the sun, it is a dingy black or dusky brown. On being aroused from sleep, the side which is first awakened assumes a darker shade. There is reason for believing that sunlight, apart from the warmth which accompanies it, is very grateful to the chameleon, and, in response to this stimulus, he at once begins his play of color. M. Paul Bert, a French *savant*, whose name is familiar to the readers of The Popular Science Monthly, has for some time been engaged in studying the anatomy and mechanism of these phenomena. His researches are not yet completed, but we may state some of the facts which he has established.

In the skin of the chameleon he finds a close net-work of minute ducts, connecting with pigment-vesicles situated on its under surface. When the coloring-liquid is all retained in these vesicles, the animal's skin appears yellowish, that being the color of the semi-transparent epidermis. When the liquid is injected into the ducts, the color of the animal changes, the tint depending on the degree of tension in the ducts. If a nerve be cut, the region of the chameleon's body to which that nerve was distributed becomes at once a deep black, and no more color-changes occur over that area. If a piece of the skin be placed under a microscope, it will appear black. Pass a current of electricity through it, and there will be seen white vacuoles, which coalesce into irregularly-shaped masses, and these in turn break up into minute vacuoles again, leaving the field of a greenish color. Stop the current, and the reverse order of phenomena appears. M. Bert finds that the effect of curare on the chameleon is to give it a very dark color, while chloroform, on the contrary, lightens the tint; but when given in quantity sufficient to destroy the animal's life, chloroform darkens the color. Bert is disposed to believe that the chameleon possesses a special set of "color-nerves" distinct from the motor and sensory systems, and that these nerves are under the control of the will.

THE ENGLISH OBSERVATORIES.

TRANSLATED FROM THE FRENCH, BY EMMA M. CONVERSE.

THE English Astronomer Royal has in his possession a very curious collection of papers, including letters that have been addressed to him by persons of every condition, in which they ask his price for casting a horoscope. In spite of such simplicity, England is one of the countries where the taste for practical astronomy is very widely diffused, and also the one where the greatest number of public and private observatories is found. Establishments of the last category abound in the United Kingdom, and attest by their number and importance the popularity of the most sublime of the sciences. There are at the present time forty observatories in the British Isles, and fifteen in the English colonies; this is a quarter of the total number that is found in the whole globe, for there are in Europe something like a hundred and twenty establishments meriting this name, and about two hundred in the entire world.

The Royal Observatory of Greenwich takes the lead, for its past labors as well as for its present position, over the other establishments of the same kind possessed by the English. It was founded in 1675, three years after the Observatory of Paris. Charles II. chose a locality for the edifice on a hill commanding the Thames and the passage of vessels, so that his astronomers would be able, by the study of the movements of the heavens, to direct the distant courses of ships over the surface of the sea. The interest of the marine was in reality the controlling motive that determined the foundation of this establishment. The ordinance of 1673 decrees that "the astronomer royal shall devote his time to rectifying the tables of celestial bodies and the positions of the fixed stars in order to obtain the means of finding the longitude at sea." To indicate in a precise manner the position of the stars, to predict with certainty the course of the moon in relation to these fixed data, is the great work reserved for sedentary astronomy in the progressive improvement of the art of navigation. The heavens constitute, as it were, a revolving dial-plate, on which the moon, making her way from star to star, marks for the navigator the absolute time, the time at Greenwich, while the height of the sun above the horizon furnishes the time of the place where he chances to be, and it is by comparison that he finds out his longitude, that is, the meridian under which he is passing. The regular and long-continued observation of the fixed stars, sun and moon, was then traditional in this illustrious establishment of Greenwich, which has had for directors such astronomers as Flamsteed, Halley, Bradley, Maskelyne, Pond, and George-Biddell Airy, who has been director since 1835. It is there that the first foundation of modern astronomy has been laid, that is to say, the astronomy of precision. Far from seeking an easily-obtained glory in the discoveries, more brilliant than really important, that strike the mind of the crowd, the Greenwich astronomers have invariably applied themselves to the laborious investigation of those minutiæ upon which the edifice of science reposes, and where often the trace of great unknown laws is revealed.

Flamsteed, the first director, made all his observations by the aid of a sextant and a mural arc, which were his own private property; the first reports were printed without his consent, and were so imperfect that he burned all of the first edition that had not been distributed, in order to have a new one made under his own inspection, and at his own expense. His successor, Halley, found the building stripped of all the apparatus; the heirs of Flamsteed had carried away every thing. This was perhaps a piece of good fortune for science, as Halley was obliged to procure new instruments, and in 1721 he caused a transit instrument to be constructed. This became the prime mover in astronomical researches, and the observations that Bradley made with its aid are the points of departure for our catalogues of the stars, for they permit us to appreciate with certainty the changes that have been brought about by time in the relative situation of the fixed stars, and consequently to reduce the observations of each day to a given epoch.

When Bradley was called, in 1742, to the direction of the Greenwich Observatory, he was already celebrated by discoveries of the first order, and known as an accomplished observer. It has always been thus; the scientific men who have been successively placed at the head of this establishment were, at the time of their nomination, perfectly familiar with the routine of their profession. They have all in like manner devoted themselves with special zeal to the improvement of instruments, and to the perfection of methods; the result has been that happy stability in principles, that continuity in labors, which is the first condition for the success of researches destined to reveal to us the slow variations that are going on in the system of the world.

Greenwich is so much the more free to concentrate all its efforts upon the astronomy of precision, as numerous observatories around it, erected by opulent universities, or due to the enlightened initiative of some rich proprietors and the great merchants of the city, share the labors that the central establishment leaves out of its programme. Oxford possesses an important observatory, founded in 1771, by the aid of a legacy of Dr. Radcliffe, now under the direction of the Rev. Robert Main, and the university has decided to found a second one. Cambridge has the Trinity Observatory, that Mr. Airy directed from 1827 to 1835, and which is now intrusted to Mr. Adams; the University of Durham possesses also a very well-organized observatory, founded by the city thirty years since.

The observatory of Liverpool was created specially for the study of marine chronometers. There, the numerous ships that enter the port of the Mersey can have their timepieces regulated. The "chronometrical chamber" is a vast sweating-room, warmed by steam; each of the hundred marine-watches that the observatory can study at the same time is inclosed in a glass case, in which the air is still heated by a gas-burner, supplied with a regulator, in order to be able to carry the temperature successively from 10° to 18° and to 27° Centigrade. After having tried in this chamber the chronometers that have been intrusted to him by the marine, the observer returns them with the table of their movements.

The Edinburgh Observatory was built in 1818, on Calton Hill, situated northeast of the city, where there has been in existence since the last century an old tower destined for observations of all kinds. The foundation of this establishment was due in the beginning to an astronomical society, organized for this purpose in the ancient capital of Scotland; but, not being able to pay for the instruments ordered, nor to appoint astronomers, it was decided in 1834 to yield the observatory to the Government. The first "astronomer royal for Scotland," charged with the direction of the Edinburgh Observatory, was Henderson, who returned there from the Cape of Good Hope. His successor, Mr. Piazzi Smyth, has established on Calton Hill a time-gun, a cannon of twenty pounds, which, fired by means of an electric current at one o'clock in the afternoon, signals the time to the mariners, and gives them the means of regulating their chronometers. For some years, the signal was given by a time-ball, as at Greenwich, Glasgow, and elsewhere; this is a great ball suspended from an elevated standard, and made to fall at a precise moment by means of electrical mechanism. Unfortunately, the Edinburgh Observatory is a victim to the centralizing tendencies that rule now in England; its budget is very much reduced, and it is hardly permitted to vegetate. The Royal Observatory of Dublin, founded in 1774, and now under the direction of Mr. Brunnow, Astronomer Royal for Ireland, is not in much better condition. On the contrary, the observatory of the University of Glasgow, and the Ecclesiastical Observatory of Armagh, founded by the Irish primate, are well operated, and render real service.

The celebrated establishment of Kew, which depends at the same time upon the British Association for the Advancement of Science, and upon the Royal Society of London, is the central meteorological observatory of England; new apparatus and new methods are studied there; besides, astronomy, so called, increases its resources by the application of photography to the study of celestial phenomena. Mr. Warren de La Rue has here inaugurated his process of solar observation by the aid of photoheliography, the first decisive step in the eminently fruitful path, the earliest idea of which is due to two French scientists, MM. Fizeau and Léon Foucault.

Mr. Warren de La Rue, who very recently presided over the Astronomical Society of London, is the largest paper-manufacturer in England, and a noteworthy improvement in photographic paper is due to him. He had since 1852 a small observatory at his house in Canonbury, at London, where he undertook his first essays in celestial photography. Five years later, he transported it to the village of Cranford, at the west of London, and since then he has divided his leisure time between this residence, where he studied the moon, and Kew, where solar investigations were carried on under his direction. At the same time, he has given his attention to the improvement of optical instruments. He made himself the mirror of a telescope that he used in most of his observations. But these labors injured his eyesight, and, despairing of being able any longer to make observations himself, he has presented his magnificent collection of instruments to the University of Oxford.

Rich merchants and opulent manufacturers have done themselves honor in founding a series of small observatories, that by their useful labors have assisted the progress of science. That of Mr. Bishop, for instance, erected at first near Regent's Park, then transported to Twickenham, where Messrs. Hind and Pogson discovered so many asteroids; that of Mr. Barclay, the brewer, at Leyton, near London; that of Mr. Lassell, near Liverpool. Like the elder Herschel and Lord Rosse, Mr. Lassell made with his own hands the mirrors of his telescopes, by whose aid he discovered the satellites of Neptune, Saturn, and Uranus. The last telescope of his construction had four feet of aperture, and was thirty-seven feet long. The impure atmosphere of a manufacturing centre like Liverpool prevented the utilization of the whole power of an instrument of such dimensions. Mr. Lassell resolved to transport it to Malta, where he had already installed, ten years before, a telescope of twenty feet. From 1862 to 1865 the new telescope was constantly turned toward the sky, and employed in scrutinizing its depths. Mr. Lassell discovered more than 600 new nebulæ, whose feeble light, under the humid sky of the North, had escaped the investigations of William Herschel and Lord Rosse. Mr. Lassell is now occupied in the publication of the numerous materials gathered during his two sojourns at Malta.

What an example and what instruction may be found in the long career of William Herschel, who passed half a century in sounding the mysterious depths of the universe! The son of a poor musician—burdened with a numerous family—he embraced the paternal profession, and went, when twenty years old, to try his fortune in England. He barely earned a living by giving music-lessons and directing concerts or oratorios, when he was appointed organist at Halifax, then soon after filled the same office in Bath. He passed his leisure time in studying works on astronomy. As he was not rich enough to purchase a telescope, he went to work, and, after a thousand attempts, succeeded in making, in 1774, a five-foot reflector, with which he observed Saturn's ring. Encouraged by this first success, the organist of Bath entered upon the construction of mirrors of seven feet, then ten, and twenty feet of focus. He made more than 200 before attaining the desired perfection, and the total number of mirrors that he worked upon in succession exceeded 400. In 1781 he had the good fortune to discover the planet Uranus, which extended the boundary of the solar system. He was then forty-three years old. This discovery drew upon him the attention of Europe; George III. granted him a pension and a dwelling at Slough, near Windsor Castle. He then commenced that methodical review of the heavens, by means of which he discovered more than 2,000 nebulæ, and suggested so many new views of the universe. The greatest part of his labor was executed with instruments of moderate dimensions; he rarely used the great telescope of forty feet, the mirror of which was easily tarnished by the action of the moisture of the night; he used it, however, in the discovery of the sixth satellite of Saturn. William Herschel died in 1822; the year before his death, at the age of eighty-three, he communicated his last paper to the Astronomical Society of London, which, since its foundation, had chosen him for president. In all his researches he was assisted by his sister Caroline, who had lived with him ever since she was twenty-two years old, and who aided him in his observations as well as in his calculations. In this way he was able to astonish the scientific world by the rapidity with which his publications succeeded each other. Caroline

Herschel died at Hanover, her native city, in 1849, at the age of ninety-eight. Sir John Herschel, the only son of the great astronomer, worthily continued these illustrious traditions. He resumed and completed the exploration of the heavens commenced by his father, at first at Slough, then at the Cape of Good Hope, where he transported a telescope of twenty feet. He died in 1871, after having contributed, by labors of the highest order, to the progress of science. One of his sons, Alexander Herschel, is equally devoted to astronomical pursuits.

The gigantic telescope of Lord Rosse, which was finished in 1845, the same year when the noble lord was elected representative peer of Ireland, is fifty-five feet in length, and has six feet of aperture. The mirror weighs over four tons, the tube seven tons, and the total weight exceeds eleven tons. The Leviathan, as this giant telescope is called, is suspended between two stone walls at Birr Castle, the hereditary residence of Lord Rosse, in King's County, Ireland. When, in 1826, the young Lord Oxmantown—the title that he then bore—turned his attention toward practical astronomy, there was no constructor capable of furnishing instruments such as he desired. William Herschel had kept the secret of the alloy he used for his mirrors, and the process by which he constructed them. James Short, the greatest constructor of the eighteenth century, so skillful in casting and polishing mirrors, had burned and destroyed before his death his whole stock of tools, in order to remain without a rival. Every thing was then to be discovered anew, and it took Lord Rosse twenty years before he attained the construction of a mirror by means of which he could sound the depths of space and resolve into a mass of stars the most of the nebulæ toward which he directed his gigantic instrument. All the nebulæ, however, are not resolvable; some of them are decidedly agglomerations of cosmical matter not yet condensed. Lord Rosse was the first to demonstrate that the great nebula of Orion, one of the finest in the heavens that belongs to the last category, has within a few years changed its appearance in consequence of the concentration of the matter of which it is formed. This celebrated observer died in 1867; his son worthily continues the labors commenced by the father with such brilliant success.

Lord Rosse preferred mirrors to objectives, on account of the difficulty that attends the manufacture of objectives of large dimensions. But great improvements have since been made; Mr. Clark, an American, constructed in 1862 a powerful instrument, with an object-glass of eighteen and a half inches of aperture. Messrs. Cooke & Son, celebrated constructors of York, finished in 1868 an equatorial of twenty-five inches of aperture, and twenty-nine feet of focal length. The telescope of this gigantic apparatus is mounted on an iron column 350 feet high, and weighs nearly ten tons. This equatorial was constructed for Mr. Newall, proprietor of the submarine cable-works at Gateshead, near Newcastle; it is destined for the island of Madeira, where it will be installed at the same time with a meridian circle of very large dimensions. Under a sky of exceptional transparency these fine instruments will serve for important researches in the hands of an experienced astronomer, Mr. Marth, the former assistant of Mr. Lassell.

The question of the constitution of nebulæ entered upon a new phase by the appearance of spectrum analysis among the methods applicable to the study of celestial bodies. Since 1869, Messrs. Huggins and Miller have concentrated all their efforts upon this department of research. They have discovered that the unresolvable nebulæ are masses of incandescent gas—they are suns in process of formation; while the resolvable nebulæ are masses of solid matter, hosts of suns already formed. It has also been established by the aid of the spectroscope that comets have a light of their own independent of that which comes from the sun, and is reflected by these wandering stars. These discoveries will give to the little observatory of Upper Tulse Hill an honorable mention in the history of astronomy.

On his side, Mr. Norman Lockyer, at Hampstead, devotes himself to the spectroscopic study of the sun. He sought for a long time to discover a process for observing in a regular manner the rosy protuberances on the solar border, which had thus far been seen only during total eclipses. Hoping that the spectroscope would betray the presence of the red flames on the *contour* of the star at ordinary times, Mr. Lockyer constructed an apparatus of several prisms, and in October, 1868, succeeded in discovering the traces of a protuberance in the spectrum of the solar border. Two months previous, M. Janssen, a French astronomer, who went to India to observe the total eclipse of the 19th of August, was in possession of an analogous method for the study of protuberances, but the announcement of his discovery reached Europe on the very day when Mr. Lockyer announced his own to the scientific world. By enlarging the slit of the spectroscope, the red flames can be seen directly, and the rapid changes followed. Astronomers now draw them at any time. Two years since, Mr. Lockyer succeeded in producing artificial eclipses of the sun by the interposition of a copper disk, which plays the *rôle* of the moon in eclipses, and he thus obtained several drawings of the solar atmosphere with all its minute details.

Mr. Carrington, at Redhill, has chosen another specialty; he has devoted eight years to a long series of observations of solar spots, which have led to remarkable conclusions relative to the constitution of the sun: the unequal velocity of rotation of the different regions of the solar globe would prove the existence of immense currents in the atmosphere of this star. The observatory of Mr. Isaac Fletcher, at Tarn-Bank, Cumberland, was created for the systematic study of double stars, a study which had also for many years occupied the attention of Admiral Smyth, at the observatory of Hartwell, where he was installed by his friend Dr. Lee. During the last year, one of the rich proprietors of Scotland, Lord Lindsay, founded a splendid observatory at Dun-Echt, for the study of Jupiter's satellites, which Mr. Airy had recommended as the best means for obtaining a knowledge of the mass of that planet. At the same time that he installed his instruments, Lord Lindsay organized at great expense—estimated at $80,000—an expedition to observe at Mauritius the transit of Venus, which took place on the 8th of December, 1874.

This division of labor into numerous specialties is very important for the progress of general science. "Then only," said Bacon, "men will begin to know their strength—when no more all will wish to do the same thing, but the one this, and the other that." The application of photography and spectroscopy to the study of celestial bodies by independent astronomers opens to physical astronomy an entirely new horizon, and promises to this branch a most rapid development. At the same time, it is clear that private establishments cannot be relied upon for the extended researches that demand the continuous labor of many generations of observers. The creation of a public observatory, assured of a permanent existence, and exclusively devoted to researches in physical astronomy, appeared then desirable and expedient. This chasm has just been filled by the foundation of the Oxford Observatory, for the construction of which the senate of that powerful university voted last year considerable funds, and to which Mr. Warren de La Rue presented all his instruments, and especially his famous reflector and his machine for working and polishing mirrors.

The British Association for the Advancement of Science, and the Royal Astronomical Society have exerted a happy influence upon the development of the observatories as well as other English scientific institutions, by creating a tie between learned men led by the same aspirations, in provoking a generous emulation, and in stimulating private enterprise by great examples. By its monthly bulletin, the *Monthly Notices*, the Astronomical Society assures to the useful efforts of amateurs that publicity which is the most powerful incentive to a disinterested devotion.

The numerous and vast colonies that compose the British Empire have not remained, in this respect, behind the mother-country. British India possesses several observatories, of which the first was founded in 1819, at Madras, by the East India Company. In 1841, the King of Oude, still independent at that epoch, erected a rival establishment at Lucknow, and installed there the astronomer Wilcox, with three native assistants. Eight years after, Wilcox having died, the observatory was suppressed, the registers of observation were eaten by the white ants, and the instruments were destroyed during the war that ended by the annexation of Oude. The Rajah of Travancore founded, on the Malabar coast, the observatory of Trevandérem, which has furnished specially good meteorological and magnetic observations. Finally, there exists at Madras a private observatory, belonging to Mr. Burton Powell.

The Cape of Good Hope was an astronomical station long before a permanent observatory was thought of. From 1751 to 1753 the celebrated Abbé de La Caille prepared his catalogue of the stars of the southern heavens, at the same time that he measured a meridional arc, and that he determined with Lalande, who had been sent to Berlin, the parallax of the moon, by means of a series of simultaneous observations. The immense labors accomplished by La Caille, in his short abode at the Cape, are so much the more worthy of praise as he had to struggle against a climate unfavorable for observation, for in this latitude there are only two months when the days are calm and serene; during the rest of the year the weather is variable, or a violent south wind fills the air with dust, and deprives it of its transparency. In spite of these inconveniences, the Cape is from its geographical situation one of the best stations for the study of the southern heavens, without taking into the account that the necessities of navigation demand the maintenance of an observatory in these regions. But it was not till 1820 that the English Admiralty decided upon the foundation of an observatory at the Cape, which should be constructed upon the model of that of Greenwich. The first director was the Rev. Fearon Fallows, who began regular observations in 1829; but, soon left alone by the departure of his assistant, he was obliged to avail himself of the assistance of his wife, who observed with the mural circle, while he made use of the transit instrument. Fallows died in 1831, and was succeeded by Henderson, to whom Sir Thomas Maclear succeeded in 1834. Better provided with instruments and *personnel* than his predecessor, Mr. Maclear resumed the geodesic operations of La Caille, and measured anew, with the superior means at his command, a meridian arc more extended than the former. Among the other works of the establishment, noteworthy mention must be made of numerous cometic observations. Mr. Maclear resigned his office in 1870, and was replaced by a Greenwich astronomer, Mr. Stone. It should be mentioned here that, outside of the Royal Observatory, Sir John Herschel prepared, from 1833 to 1838, at the Cape of Good Hope, his celebrated catalogue of the nebulæ and double stars of the southern heavens, by the aid of a telescope and an equatorial which he had brought with him.

Since the abode of La Caille at the Cape, no serious attempt had been made to add to our knowledge of the southern half of the heavens, when, in 1821, Sir Thomas Brisbane, then governor of the colony of New South Wales, resolved to supply the want at his own expense. He founded three observatories, one at Makerstown, where Mr. Allen Brown, who has since become the astronomer of the Rajah of Travancore, began a series of meteorological and magnetic observations, the two others at Brisbane and at Paramatta near Sydney. Of the last two, only that of Paramatta was utilized; the astronomers Rumker and Dunlop prepared there precious catalogues of stars mostly invisible in our hemisphere. Abandoned after the death of Dunlop, this establishment was suppressed in 1855, and replaced by the observatory of Sydney, that the government of New South Wales caused to be constructed at its own expense to satisfy the complaints of the mariners, who found in these regions no means for regulating their chronometers. Already, two years before, the rapid increase of navigation between Europe and Australia in consequence of the discovery of the gold-mines had led the government of the colony of Victoria to found an observatory at Melbourne, which, under the intelligent direction of Mr. Ellery, quickly took rank among the most active establishments. Melbourne has possessed since 1870 a telescope of colossal dimensions. The tube and the mirror, which is four feet in diameter, weigh together nearly nine tons, and the clockwork movement that regulates this immense machine is of such precision that the wire of the micrometer follows a fixed star for more than an hour. As a precautionary measure, two four-feet mirrors were sent from London instead of one; unfortunately, they were both injured in the passage, it was necessary to repolish them, and, in spite of the impatience and bad humor of the inhabitants of Melbourne, all the results promised from this great telescope have not yet been attained. Instruments of this kind are so much the more delicate as their dimensions are increased, and they demand long practice before being used with success. At present the greater part of the work of the Melbourne establishment is carried on with the ordinary implements of observatories. Mr. Ellery arranged with the astronomers at Sydney and at the Cape for undertaking a grand review of the southern heavens, which were divided into zones, and the three stations shared the systematic exploration. A large portion of these observations has been already published.

The rapid picture we have sketched will give an idea of the extraordinary flight practical astronomy has taken not only on the soil of the British Isles, but upon every point of the globe where the Anglo-Saxon race has planted its colonies. The necessities of navigation have been the prominent motive for the creation of some of the most important English observatories; but the volunteers in science have also done no inconsiderable portion of the common work. The landed aristocracy, the higher branches of trade, the arts and manufactures, hold the honor of being united with the professional men of science, or at least of coöperating in their labors, by an enlightened munificence. Can a better use be made of fortune or leisure? It has been said concerning the organization of the Greenwich Observatory that the essentially practical and utilitarian spirit of the English is manifested also in science, since all the labor in Greenwich is directed toward a special purpose, the incessant improvement of that portion of astronomy that renders so great service to navigation. However, in seeing that varied activity displayed in the numerous observatories of Great Britain, and including in its sphere every branch of celestial science, must it not be granted that something else is developed besides a tendency to the positive or the research of applications immediately useful?

It is worthy of note that the efforts of amateurs are particularly directed toward the realization of instruments of unusual dimensions, destined to sound the depths of the firmament. But the construction of mirrors or object-glasses of very great diameter is of fundamental interest for the progress of physical astronomy. Not only is the brightness of images proportioned to the aperture, that is, to the diameter of the instrument, but the optical power, or the faculty of separating two luminous points closely united, increases also in a direct ratio with the aperture. According to Léon Foucault, an aperture of at least thirty-nine inches is required to distinguish two points from each other whose apparent distance is equal to the tenth of a second of an arc. The two Herschels, Lord Rosse, Mr. Lassell, finally the commission that had charge of the construction of the Melbourne telescope, gave the preference to telescopes with a metallic mirror; is this preference justifiable? The question admits of doubt. The mirrors of silvered glass in which Léon Foucault attained so great perfection reflect a larger portion of light than metal mirrors; according to the experience of Mr. Wolf, a telescope with a silvered mirror reflects 80 per cent. of the incident light, while with metallic mirrors only 40 per cent. can be utilized. Besides, glass mirrors are lighter, and it is easy to silver them anew when the surface is tarnished. Metal mirrors need to be frequently repolished, which is no inconsiderable work; the experience at Melbourne affords an illustration of this fact. It is then with good reason that telescopes of the Foucault system are preferred in France. Finally, to sum up every thing, the future is perhaps not for great mirrors, but for great object-glasses. Indeed, with an equal aperture, a refracting telescope furnished with a good object-glass far surpasses a reflecting telescope; the great refractors of Dorpat and Pultowa rival reflectors of a double or triple diameter. We have already seen that a refractor of twenty-five inches aperture has been completed by Messrs. Cooke. The Observatory of Paris has possessed since 1855 a disk of flint-glass and one of crown-glass whose dimensions are sufficient to make an object-glass of nearly thirty inches in diameter, and in 1868 the Government voted $80,000 for the construction of a refractor which should be furnished with this object-glass and for that of a reflector with nearly four feet aperture. The mirror of the reflector, the work of which was intrusted to Mr. Martin, is almost finished; the cutting of the object-glass will be immediately commenced. This will be the most powerful glass that has yet been undertaken, and this time it is France that will take the precedence of other nations. It is hoped that this will not be the only effort attempted for the purpose of making practical astronomy flourish among us with a splendor worthy of a glorious past.

THE ATMOSPHERE IN RELATION TO FOG-SIGNALING.

By JOHN TYNDALL, LL. D., F. R. S.

INTRODUCTION.

THE cloud produced by the puff of a locomotive can quench the rays of the noonday sun; it is not therefore surprising that in dense fogs our most powerful coast-lights, including even the electric light, should become useless to the mariner.

Disastrous shipwrecks are the consequence. During the last ten years no less than 273 vessels have been reported as totally lost on our own coasts in fog or thick weather. The loss, I believe, has been far greater on the American seaboard, where trade is more eager and fogs more frequent than they are here. No wonder, then, that earnest efforts should be made to find a substitute for light in sound-signals, powerful enough to give warning and guidance to mariners while still at a safe distance from the shore.

Such signals have been established to some extent upon our own coasts, and to a still greater extent along the coasts of Canada and the United States. But the evidence as to their value and performance is of the most conflicting character, and no investigation sufficiently thorough to clear up the uncertainty has hitherto been made. In fact, while the *velocity* of sound has formed the subject of refined and repeated experiment by the ablest philosophers, the publication of Dr. Derham's celebrated paper in the "Philosophical Transactions" for 1708 marks the latest systematic inquiry into the causes which affect the *intensity* of sound in the atmosphere.

Jointly with the Elder Brethren of the Trinity House, and as their scientific adviser, I have recently had the honor of conducting an inquiry designed to fill the blank here indicated.

One or two brief references will suffice to show the state of the question when this investigation began. "Derham," says Sir John Herschel, "found that fogs and falling rain, but more especially snow, tend powerfully to obstruct the propagation of sound, and that the same effect was produced by a coating of fresh-fallen snow on the ground, though when glazed and hardened at the surface by freezing it had no such influence." [1]

In a very clear and able letter addressed to the President of the Board of Trade in 1863,[2] Dr. Robinson, of Armagh, thus summarizes our knowledge of fog-signals:

[1] "Essay on Sound," par. 21. [2] "Report of the British Association" for 1863, p. 105.

"Nearly all that is known about fog-signals is to be found in the 'Report on Lights and Beacons;' and of it much is little better than conjecture. Its substance is as follows:

"'Light is scarcely available for this purpose. Blue lights are used in the Hoogly; but it is not stated at what distance they are visible in fog; their glare may be seen farther than their flame.[1] It might, however, be desirable to ascertain how far the electric light or its flash can be traced.[2]

"'Sound is the only known means really effective; but about it testimonies are conflicting, and there is scarcely one fact relating to its use as a signal which can be considered as established. Even the most important of all, the distance at which it ceases to be heard, is undecided.

"'Up to the present time all signal-sounds have been made in air, though this medium has grave disadvantages: its own currents interfere with the sound-waves, so that a gun or bell which is heard several miles *down* the wind is inaudible more than a few furlongs *up* it. A still greater evil is that it is least effective when most needed; for fog is a powerful damper of sound.'"

Dr. Robinson here expresses the universally prevalent opinion, and he then assigns the theoretic cause. Fog, he says, "is a mixture of air and globules of water, and, at each of the innumerable surfaces where these two touch, a portion of the vibration is reflected and lost.[3] . . . Snow produces a similar effect, and one still more injurious."

Reflection being thus considered to take place at the surfaces of the suspended particles, it followed that the greater the number of particles, or, in other words, the denser the fog, the more injurious would be its action upon sound. Hence optic transparency came to be considered a measure of acoustic transparency. On this point Dr. Robinson, in the letter referred to, expresses himself thus: "At the outset, it is obvious that, to make experiments *comparable*, we must have some measure of the fog's power of stopping sound, without attending to which the most anomalous results may be expected. It seems probable that this will bear some simple relation to its opacity to light, and that the distance at which a given object, as a flag or pole, disappears, may be taken as the measure. . . . Still, clear air" was regarded in this letter as the best vehicle of sound, the alleged action of fogs, rain, and snow, being ascribed to their rendering the atmosphere "a discontinuous medium."

Prior to this investigation the views here enunciated were those universally entertained. That sound is unable to penetrate fogs was taken to be "a matter of common observation." The bells and horns of ships were affirmed "not to be heard so far in fogs as in clear weather." In the fogs of London, the noise of the carriage-wheels was reported to be so much diminished that "they seem to be at a distance when really close by." My knowledge does not inform me of the existence of any other source for these opinions regarding the

[1] A very sagacious remark, as observation proves.

[2] Powerful electric lights have been since established, and found ineffectual.

[3] This is also Sir John Herschel's way of regarding the subject. "Essay on Sound," par. 38.

deadening power of fog than the paper of Derham, published one hundred and sixty-seven years ago. In consequence of their *a priori* probability, his conclusions seem to have been transmitted unquestioned from generation to generation of scientific men.

Instruments and Observations.—On the 19th of May, 1873, this inquiry began. The South Foreland, near Dover, was chosen as the signal-station, steam-power having been already established there to work two powerful magneto-electric lights. The observations were mostly made afloat, one of the yachts of the Trinity Corporation being usually employed for this purpose. Two stations had been established, one at the top, the other at the bottom, of the South-Foreland Cliff; and, at each, trumpets, air-whistles, and steam whistles of great size, were mounted. The whistles first employed were of English manufacture. To these were afterward added a large United States whistle, also a Canadian whistle, of great reputed power.

On the 8th of October another instrument, which has played a specially important part in these observations, was introduced. This was a steam-siren, constructed and patented by Mr. Brown, of New York, and introduced by Prof. Henry into the light-house system of the United States. As an example of international courtesy worthy of imitation, I refer with pleasure to the fact that, when informed by Major Elliott, of the United States Army, that our experiments had begun, the Light-house Board at Washington, of their own spontaneous kindness, forwarded to us for trial a very noble instrument of this description, which was immediately mounted at the South Foreland.

The principle of the siren is easily understood. A musical sound is produced when the tympanic membrane is struck periodically with sufficient rapidity. The production of these tympanic shocks by puffs of air was first realized by Dr. Robinson, and his device was the first and simplest form of the siren. A stopcock was so constructed that it opened and shut the passage of a pipe 720 times in a second. Air from the wind-chest of an organ being allowed to pass along the pipe during the rotation of the cock, a musical sound was most smoothly uttered. A great step was made in the construction of the instrument by Cagniard de la Tour, who gave it its present name. He employed a box with a perforated lid, and above the lid a similarly perforated disk capable of rotation. The perforations were oblique, so that when wind was driven through the lid, it so impinged upon the apertures of the disk as to set it in motion. No separate mechanism was therefore required to turn the disk. When the perforations of lid and disk coincided, a puff escaped; when they did not coincide, the current of air was cut off. In this way impulses were imparted to the air, and sound-waves generated. The siren has been greatly improved by Dove, and specially so by Helmholtz. Even in its small form, it can produce sounds of great intensity.

In the steam-siren, as in the ordinary one, a fixed disk and a rotating disk are employed, but radial slits are used instead of circular apertures. One disk is fixed vertically across the throat of a conical trumpet 16½ feet long, 5 inches in diameter where the disk crosses it, and gradually opening out till at the other extremity it reaches a diameter of two feet three inches. Behind the fixed disk is the rotating one, which is driven by separate mechanism. The trumpet is mounted on a boiler. In our experiments, steam of 70 lbs. pressure was for the most part employed. Just as in the ordinary siren, when the radial slits of the two disks coincide, and then only, a strong puff of steam escapes. Sound-waves of great intensity are thus sent through the air, the pitch of the note depending on the velocity of rotation.

To the siren, trumpets, and whistles, were added three guns—an 18-pounder, a 5½-inch howitzer, and a 13-inch mortar. In our summer experiments all three were fired; but the howitzer having shown itself superior to the other guns, it was chosen in our autumn experiments, as not only a fair but a favorable representative of this form of signal. The charges fired were for the most part those now employed at Holyhead, Lundy Island, and the Kish light-vessel—namely, 3 lbs. of powder. Gongs and bells were not included in this inquiry, because previous observations had clearly proved their inferiority to the trumpets and whistles.

On the 19th of May the instruments tested were:

On the top of the cliff:

1. Two brass trumpets or horns, 11 feet 2 inches long, 2 inches in diameter at the mouthpiece, and opening out at the other end to a diameter of 22½ inches. They were provided with vibrating steel reeds 9 inches long, 2 inches wide, and ¼ inch thick, and were sounded by air of 18 lbs. pressure.

2. A whistle shaped like that of a locomotive, 6 inches in diameter, also sounded by air of 18 lbs. pressure.

3. A steam-whistle, 12 inches in diameter, attached to a boiler, and sounded by steam of 64 lbs. pressure.

At the bottom of the cliff:

4. Two trumpets or horns, of the same size and arrangement as those above, and sounded by air of the same pressure. They were mounted vertically on the reservoir of compressed air; but within about two feet of their extremities they were bent at a right angle, so as to present their mouths to the sea.

5. A 6-inch air-whistle, similar to the one above, and sounded by the same means.

The upper instruments were 235 feet above high-water mark, the lower ones 40 feet. A vertical distance of 195 feet, therefore, separated the instruments. A shaft, provided with a series of twelve ladders, led from the one to the other.

Comparative experiments made at the outset gave a slight advantage to the upper instruments. They, therefore, were for the most part employed throughout the subsequent inquiry.

Our first experiments were a preliminary discipline rather than an organized effort at discovery. On May 19th the maximum distance reached by the sound was about $3\frac{1}{2}$ miles.[1] The wind, however, was high and the sea rough, so that local noises interfered to some extent with our appreciation of the sound.

Mariners express the strength of the wind by a series of numbers extending from 0 = calm to 12 = a hurricane, a little practice in common producing a remarkable unanimity between different observers as regards the force of the wind. Its force on May 19th was 6, and it blew at right angles to the direction of the sound.

The same instruments on May 20th covered a greater range of sound; but not much greater, though the disturbance due to local noises was absent. At four miles' distance in the axes of the horns they were barely heard, the air at the time being calm, the sea smooth, and all other circumstances exactly those which have been hitherto regarded as most favorable to the transmission of sound. We crept a little farther away, and by stretched attention managed to hear at intervals, at a distance of six miles, the faintest hum of the horns. A little farther on we again halted; but though local noises were absent, and though we listened intently, we heard nothing.

This position, clearly beyond the range of whistles and trumpets, was expressly chosen with the view of making what might be considered a decisive comparative experiment between horns and guns as instruments for fog-signaling. The distinct report of the twelve o'clock gun fired at Dover on the 19th suggested this comparison, and through the prompt courtesy of General Sir A. Horsford we were enabled to carry it out. At half-past twelve precisely the puff of an 18-pounder, with a three-lb. charge, was seen at Dover Castle, which was about a mile farther off than the South Foreland. Thirty-six seconds afterward the loud report of the gun was heard, its complete superiority over the trumpets being thus, to all appearance, demonstrated.

We clinched this observation by steaming out to a distance of $8\frac{1}{2}$ miles, where the report of a second gun was well heard by all of us. At a distance of 10 miles the report of a third gun was heard by some, and at 9.7 miles the report of a fourth gun was heard by all.

The result seemed perfectly decisive. Applying the law of inverse squares, the sound of the gun at a distance of 6 miles from the Foreland must have had more than two and a half times the intensity of the sound of the trumpets. It would hardly have been rash under the circumstances to have reported without qualification the superiority of the gun as a fog-signal. No single experiment is, to my

[1] In all cases nautical miles are meant.

knowledge, on record to prove that a sound once predominant would not be always predominant, or that the atmosphere on different days would show preferences to different sounds. On many subsequent occasions, however, the sound of the horns proved distinctly superior to that of the gun. This *selective* power of the atmosphere revealed itself more strikingly in our autumn experiments than in our summer ones; and it was sometimes illustrated within a few hours of the same day; of two sounds, for example, one might have the greatest range at 10 A. M., and the other the greatest range at 2 P. M.

In the experiments on May 19th and 20th the superiority of the trumpets over the whistles was decided; and, indeed, with few exceptions, this superiority was maintained throughout the inquiry. But there were exceptions. On June 2d, for example, the whistles rose in several instances to full equality with, and on rare occasions subsequently even surpassed, the horns. The sounds were varied from day to day, and various shiftings of the horns and reeds were resorted to, with a view of bringing out their maximum power. On the date last mentioned a single horn was sounded, two were sounded, and three were sounded, together; but the utmost range of the loudest sound, even with the paddles stopped, did not exceed 6 miles. With the view of concentrating their power, the axes of the horns had been pointed in the same direction, and, unless stated to the contrary, this in all subsequent experiments was the case.

On June 3d the three guns already referred to were permanently mounted at the South Foreland. They were ably served by gunners from Dover Castle.

On the same day dense clouds quite covered the firmament, some of them particularly black and threatening, but a marked advance was observed in the transmissive power of the air. At a distance of 6 miles the horn-sounds were not quite quenched by the paddle-noises; at 8 miles the whistles were heard, and the horns better heard; while at 9 miles, with the paddles stopped, the horn-sounds alone were fairly audible. During the day's observations a remarkable and instructive phenomenon was observed. Over us rapidly passed a torrential shower of rain, which, according to Derham, is a potent damper of sound. We could, however, notice no subsidence of intensity as the shower passed. It is even probable that, had our minds been free from bias, we should have noticed an augmentation of the sound, such as occurred with the greatest distinctness on various subsequent occasions during violent rain.

The influence of "beats" was tried on June 3d, by throwing the horns slightly out of unison; but, though the beats rendered the sound characteristic, they did not seem to augment the range. At a distance from the station curious fluctuations of intensity were noticed. Not only did the different blasts vary in strength, but sudden swellings and fallings off, even of the same blast, were observed. This was not due to any variation on the part of the instruments, but purely to the changes of the medium traversed by the sound. What these changes were shall be indicated subsequently.

The range of our best horns on June 10th was 8¾ miles. The guns at this distance were very feeble. That the loudness of the sound depends on the shape of the gun was proved by the fact that thus far the howitzer, with a three-lb. charge, proved more effective than the other guns.

On June 25th a gradual improvement in the transmissive power of the air was observed from morning to evening; but at the last the maximum range was only moderate. The fluctuations in the strength of the sound were remarkable, sometimes sinking to inaudibility and then rising to loudness. A similar effect, due to a similar cause, is often noticed with church-bells. The acoustic transparency of the air was still further augmented on the 26th: at a distance of 9¼ miles from the station the whistles and horns were plainly heard against a wind with a force of four; while on the 25th, with a favoring wind, the maximum range was only 6½ miles. Plainly, therefore, something else than the wind must be influential in determining the range of the sound.

On Tuesday, July 1st, observations were made on the decay of the sound at various angular distances from the axis of the horn. As might be expected, the sound in the axis was loudest, the decay being gradual on both sides. In the case of the gun, however, the direction of pointing has very little influence.

The day was acoustically clear; at a distance of 10 miles the horn yielded a plain sound, while the American whistle seemed to surpass the horn. Dense haze at this time quite hid the Foreland. At 10½ miles occasional blasts of the horn came to us, but, after a time, all sound ceased to be audible; it seemed as if the air, after having been exceedingly transparent, had become gradually more opaque to the sound.

At 4.45 P. M. we took the master of the Varne light-ship on board the Irene. He and his company had heard the sound at intervals during the day, although he was dead to windward and distant 12¾ miles from the source of sound.

Here a word of reflection on our observations may be fitly introduced. It is, as already shown, an opinion entertained in high quarters that the waves of sound are reflected at the limiting surfaces of the minute particles which constitute haze and fog, the alleged waste of sound in fog being thus explained. If, however, this be an efficient practical cause of the stoppage of sound, and if clear, calm air be, as alleged, the best vehicle, it would be impossible to understand how to-day, in a thick haze, the sound reached a distance of 12¾ miles, while on May 20th, in a calm and hazeless atmosphere, the maximum range was only from 5 to 6 miles. Such facts foreshadow a revolution in our notions regarding the action of haze and fogs upon sound.

An interval of 12 hours sufficed to change in a surprising degree the acoustic transparency of the air. On the 1st of July the sound had a range of nearly 13 miles; on the 2d the range did not exceed 4 miles.

Contradictory Results.—Thus far the investigation proceeded with hardly a gleam of a principle to connect the inconstant results. The distance reached by the sound on the 19th of May was 3½ miles; on the 20th it was 5½ miles; on the 2d of June, 6 miles; on the 3d, more than 9 miles; on the 10th it was also 9 miles; on the 25th it fell to 6½ miles; on the 26th it rose again to more than 9¼ miles; on the 1st of July, as we have just seen, it reached 12¾, whereas on the 2d the range shrunk to 4 miles. None of the meteorological agents observed could be singled out as the cause of these fluctuations. The wind exerts an acknowledged power over sound, but it could not account for these phenomena. On the 25th of June, for example, when the range was only 6½ miles, the wind was favorable; on the 26th, when the range exceeded 9¼ miles, it was opposed to the sound. Nor could the varying optical clearness of the atmosphere be invoked as an explanation; for, on July 1st, when the range was 12¾ miles, a thick haze hid the white cliffs of the Foreland, while on many other days, when the acoustic range was not half so great, the atmosphere was optically clear. Up to July 3d all remained enigmatical; but on this date observations were made which seemed to me to displace surmise and perplexity by the clearer light of physical demonstration.

Solution of Contradictions.—On July 3d we first steamed to a point 2.9 miles southwest-by-west of the signal station. No sounds, not even the guns, were heard at this distance. At two miles they were equally inaudible. But this being a position at which the sounds, though strong in the axis of the horn, invariably subsided, we steamed to the exact bearing from which our observations had been made on July 1st. At 2.15 p. m., and at a distance of 3¾ miles from the station, with calm, clear air and a smooth sea, the horns and whistle (American) were sounded, but they were inaudible. Surprised at this result, I signaled for the guns. They were all fired, but, though the smoke seemed at hand, no sound whatever reached us. On July 1st, in this bearing, the observed range of both horns and guns was 10½ miles, while, on the bearing of the Varne light-vessel, it was nearly 13 miles. We steamed in to 3 miles, paused, and listened with all attention; but neither horn nor whistle was heard. The guns were again signaled for; five of them were fired in succession, but not one of them was heard. We steamed on in the same bearing to 2 miles, and had the guns fired point-blank at us. The howitzer and the mortar, with 3-lb. charges, yielded a feeble thud, while the 18-pounder was wholly unheard. Applying the law of inverse squares, it follows that, with the air and sea, according to accepted notions, in a far worse condition, the sound at two miles' distance on July 1st must have had more than forty times the intensity which it possessed at the same distance at 3 P. M. on the 3d.

"On smooth water," says Sir John Herschel, "sound is propagated with remarkable clearness and strength." Here was the condition; still, with the Foreland so close to us, the sea so smooth, and the air so transparent, it was difficult to realize that the guns had been fired, or the trumpets blown at all. What could be the reason? Had the sound been converted by internal friction into heat, or had it been wasted in partial reflections at the limiting surfaces of non-homogeneous masses of air? I ventured, two or three years ago, to say something regarding the function of the imagination in science, and, notwithstanding the care then taken, to define and illustrate its real province, some persons, among whom were one or two able men, deemed me loose and illogical. They misunderstood me. The faculty to which I referred was that power of visualizing processes in space, and the relations of space itself, which must be possessed by all great physicists and geometers. Looking, for example, at two pieces of polished steel, we have not a sense, or the rudiment of a sense, to distinguish the inner condition of the one from that of the other. And yet they may differ materially, for one may be a magnet, the other not. What enabled Ampère to surround the atoms of such a magnet with channels in which electric currents ceaselessly run, and to deduce from these pictured currents all the phenomena of ordinary magnetism? What enabled Faraday to visualize his lines of force, and make his mental picture a guide to discoveries which have rendered his name immortal? Assuredly it was the disciplined imagination. Figure the observers on the deck of the Irene, with the invisible air stretching between them and the South Foreland, knowing that it contained something which stifled the sound, but not knowing what that something is. Their senses are not of the least use to them; nor could all the philosophical instruments in the world render them any assistance. They could not, in fact, take a single step toward the solution without the formation of a mental image; in other words, without the exercise of the imagination.

Sulphur in homogeneous crystals is exceedingly transparent to radiant heat, whereas the ordinary brimstone of commerce is highly impervious to it—the reason being that the brimstone does not possess the molecular continuity of the crystal, but is a mere aggregate of minute grains not in perfect optical contact with each other. Where this is the case, a portion of the heat is always reflected on entering and on quitting a grain; hence, when the grains are minute and numerous, this reflection is so often repeated that the heat is entirely wasted before it can plunge to any depth into the substance. The same remark applies to snow, foam, clouds, and common salt, indeed to all transparent substances in powder; they are all impervious to light, not through the immediate absorption or extinction of the light, but through repeated internal reflection.

Humboldt, in his observations at the Falls of the Orinoco, is known to have applied these principles to sound. He found the noise of the falls far louder by night than by day, though in that region the night is far noisier than the day. The plain between him and the falls consisted of spaces of grass and rock intermingled. In the heat of the day he found the temperature of the rock to be considerably higher than that of the grass. Over every heated rock, he concluded, rose a column of air rarefied by the heat; its place being supplied by the descent of heavier air. He ascribed the deadening of the sound to the reflections which it endured at the limiting surfaces of the rarer and denser air. This philosophical explanation made it generally known that a non-homogeneous atmosphere is unfavorable to the transmission of sound.

But what, on July 3d, not with the variously-heated plain of Antures, but with a calm sea as a basis for the atmosphere, could so destroy its homogeneity as to enable it to quench in so short a distance so vast a body of sound? My course of thought at the time was thus determined. As I stood upon the deck of the Irene, pondering the question, I became conscious of the exceeding power of the sun beating against my back and heating the objects near me. Beams of equal power were falling on the sea, and must have produced copious evaporation. That the vapor generated should so rise and mingle with the air as to form an absolutely homogeneous medium was in the highest degree improbable. It would be sure, I thought, to rise in invisible streams, breaking through the superincumbent air, now at one point, now at another, thus rendering the air *flocculent* with wreaths and striæ, charged in different degrees with the buoyant vapor. At the limiting surfaces of these spaces, though invisible, we should have the conditions necessary to the production of partial echoes and the consequent waste of sound. Ascending and descending air-currents, of different temperatures, as far as they existed, would also contribute to the effect.

Curiously enough, the conditions necessary for the testing of this explanation immediately set in. At 3.15 P. M., a solitary cloud threw itself athwart the sun, and shaded the entire space between us and the South Foreland. The heating of the water, and the production of vapor, were suddenly checked by the interposition of this screen; hence the probability of suddenly-improved transmission. To test this inference, the steamer was immediately turned and urged back to our last position of inaudibility. The sounds, as I expected, were distinctly though faintly heard. This was at 3 miles' distance. At 3¾ miles the guns were fired, both point-blank and elevated. The faintest pop was all that we heard; but we did hear a pop, whereas we had previously heard nothing, either here or three-quarters of a mile nearer. We steamed out to $4\frac{1}{4}$ miles, where the sounds were for a moment faintly heard; but they fell away as we waited, and though the greatest quietness reigned on board, and though the sea was without a ripple, we could hear nothing. We could plainly see the steam-puffs which announced the beginning and the end of a series of trumpet-blasts, but the blasts themselves were quite inaudible.

It was now 4 P. M., and my intention at first was to halt at this distance, which was beyond the sound-range, but not far beyond it, and see whether the lowering of the sun would not restore the power of the atmosphere to transmit the sound. But, after waiting a little, the anchoring of a boat was suggested, so as to liberate the steamer for other work; and, though loath to lose the anticipated revival of the sounds myself, I agreed to this arrangement. Two men were placed in the boat and requested to give all attention, so as to hear the sound if possible. With perfect stillness around them, they heard nothing. They were then instructed to hoist a signal if they should hear the sounds, and to keep it hoisted as long as the sounds continued.

At 4.45 we quitted them and steamed toward the South Sand Head light-ship. Precisely fifteen minutes after we had separated from them the flag was hoisted: the sound had at length succeeded in piercing the body of air between the boat and the shore.

We continued our journey to the light-ship, went on board, heard the report of the lightsmen, and returned to our anchored boat. We then learned that when the flag was hoisted the horn-sounds were heard, that they were succeeded after a little time by the whistle-sounds, and that both increased in intensity as the evening advanced. On our arrival, of course we heard the sounds ourselves.

We pushed the test further by steaming farther out. At $5\frac{3}{4}$ miles, we halted and heard the sounds; at 6 miles we heard them distinctly, but so feebly that we thought we had reached the limit of the sound-range; but while we waited the sounds rose in power. We steamed to the Varne buoy, which is $7\frac{3}{4}$ miles from the signal-station, and heard the sounds there better than at 6 miles' distance. We continued our course outward to 10 miles, halted there for a brief interval, but heard nothing.

Steaming, however, on to the Varne light-ship, which is situated at the other end of the Varne shoal, we hailed the master, and were informed by him that up to 5 P. M. nothing had been heard, but that at that hour the sounds began to be audible. He described one of them as "very gross, resembling the bellowing of a bull," which very accurately characterizes the sound of the large American steam-whistle. At the Varne light-ship, therefore, the sounds had been heard toward the close of the day, though it is $12\frac{3}{4}$ miles from the signal-station. I think it probable that, at a point 2 miles from the Foreland, the sound at 5 P. M. possessed fifty times the intensity which it possessed at 2 P. M. To such undreamt-of fluctuations is the atmosphere liable. On our return to Dover Bay, at 10 P. M., we heard the sounds, not only distinct but loud, where nothing could be heard in the morning.

Remarkable Instances of Acoustic Opacity.—In his excellent lecture entitled "Wirkungen aus der Ferne," Dove has collected some striking cases of the interception of sound. The Duke of Argyll has also favored me with some highly-interesting illustrations. But nothing of this description that I have read equals in point of interest the following account of the battle of Gain's Farm, for which I am indebted to the Rector of the University of Virginia:

"Lynchburg, Va., *March* 19, 1874.

"Sir: I have just read with great interest your lecture of January 16th, on the acoustic transparency and opacity of the atmosphere. The remarkable observations you mention induce me to state to you a fact which I have occasionally mentioned, but always, where I am not well known, with the apprehension that my veracity would be questioned. It made a strong impression on me at the time, but was an insoluble mystery until your discourse gave me a possible solution.

"On the afternoon of June 28, 1862, I rode, in company with General G. W. Randolph, then Secretary of War of the Confederate States, to Price's house, about nine miles from Richmond; the evening before General Lee had begun his attack on McClellan's army, by crossing the Chickahominy about four miles above Price's, and driving in McClellan's right wing. The battle of Gain's Farm was fought the afternoon to which I refer. The valley of the Chickahominy is about one and a half mile wide from hill-top to hill-top. Price's is on one hill-top, that nearest to Richmond; Gain's Farm, just opposite, is on the other, reaching back in a plateau to Cold Harbor.

"Looking across the valley I saw a good deal of the battle, Lee's right resting in the valley, the Federal left wing the same. My line of vision was nearly in the line of the lines of battte. I saw the advance of the Confederates, their repulse two or three times, and in the gray of the evening the final retreat of the Federal forces.

"I distinctly saw the musket-fire of both lines, the smoke, the individual discharges, the flash of the guns. I saw batteries of artillery on both sides come into action and fire rapidly. Several field-batteries on each side were plainly in sight. Many more were hid by the timber which bounded the range of vision.

"Yet, looking for nearly two hours, from about 5 to 7 P. M. on a midsummer afternoon, at a battle in which at least 50,000 men were actually engaged, and doubtless at least 100 pieces of field-artillery, through an atmosphere optically as limpid as possible, *not a single sound of the battle* was audible to General Randolph and myself. I remarked it to him at the time as astonishing.

"Between me and the battle was the deep, broad valley of the Chickahominy, partly a swamp, shaded by the declining sun, by the hills and forest in the west (my side). Part of the valley on each side of the swamp was cleared; some in cultivation, some not. Here were conditions capable of providing several belts of air, varying in the amount of watery vapor (and probably in temperature), arranged like laminæ at right angles to the acoustic waves as they came from the battle-field to me.

"Respectfully, your obedient servant, R. G. H. Kean.

"Prof. John Tyndall."

I learn from a subsequent letter that during the battle the air was still.—J. T.

Echoes from Invisible Acoustic Clouds.—But both the argument and the phenomena have a complementary side, which we have now to consider. A stratum of air less than three miles thick on a calm day has been proved competent to stifle both the cannonade and the horn-sounds employed at the South Foreland; while, according to the foregoing explanation, this result was due to the reflection of the sound from invisible *acoustic clouds* which filled the atmosphere on a day of perfect *optical* transparency. But, granting this, it is incredible that so great a body of sound could utterly disappear in so short a distance without rendering some account of itself. Supposing, then, instead of placing ourselves behind the acoustic cloud, we were to place ourselves in front of it, might we not, in accordance with the law of conservation, expect to receive by reflection the sound which had failed to reach us by transmission? The case would then be strictly analogous to the reflection of light from an ordinary cloud to an observer between it and the sun.

My first care in the early part of the day in question was to assure myself that our inability to hear the sound did not arise from any derangement of the instruments on shore. Accompanied by the private secretary of the Deputy Master of the Trinity House, at 1 P. M. I was rowed to the shore, and landed at the base of the South Foreland Cliff. The body of air which had already shown such extraordinary power to intercept the sound, and which manifested this power still more impressively later in the day, was now in front of us. On it the sonorous waves impinged, and from it they were sent back with astonishing intensity. The instruments, hidden from view, were on the summit of a cliff 235 feet above us, the sea was smooth and clear of ships, the atmosphere was without a cloud, and there was no object in sight which could possibly produce the observed effect. From the perfectly transparent air the echoes came, at first with a strength apparently little less than that of the direct sound, and then dying gradually and continuously away. A remark made by my talented companion in his note-book at the time shows how the phenomenon affected him: "Beyond saying that the echoes seemed to come from the expanse of ocean, it did not appear possible to indicate any more definite point of reflection." Indeed, no such point was to be seen; the echoes reached us, as if by magic, from the invisible acoustic clouds with which the optically transparent atmosphere was filled. The existence of such clouds in all weathers, whether optically cloudy or serene, is one of the most important points established by this inquiry.

Here, in my opinion, we have the key to many of the mysteries and discrepancies of evidence which beset this question. The foregoing observations show that there is no need to doubt either the veracity or the capability of the conflicting witnesses, for the variations of the atmosphere are more than sufficient to account for theirs. The mistake, indeed, hitherto has been, not in reporting incorrectly, but in neglecting the monotonous operation of repeating the observations during a sufficient time. I shall have occasion to remark subsequently on the mischief likely to arise from giving instruction to mariners founded on observations of this incomplete character.

It required, however, long pondering and repeated observation before this conclusion took firm root in my mind; for it was opposed to the results of great observers, and to the statements of celebrated writers. In science, as elsewhere, a mind of any depth, which accepts a doctrine undoubtingly, discards it unwillingly. The question of aërial echoes has an historic interest. While cloud-echoes have been accepted as demonstrated by observation, it has been hitherto held as established that audible echoes never occur in optically clear air. We owe this opinion to the admirable report of Arago on the experiments made to determine the velocity of sound at Montlhéry and Villejuif in 1822.[1] Arago's account of the phenomenon observed by him and and his colleagues is as follows: "Before ending this note we will only add that the shots fired at Montlhéry were accompanied by a rumbling like that of thunder, which lasted from 20 to 25 seconds. Nothing of this kind occurred at Villejuif. Once we heard two distinct reports, a second apart, of the Montlhéry cannon. In two other cases the report of the same gun was followed by a prolonged rumbling. These phenomena never occurred without clouds. Under a clear sky the sounds were single and instantaneous. May we not, therefore, conclude that the multiple reports of the Montlhéry gun heard at Villejuif were echoes from the clouds, and may we not accept this fact as favorable to the explanation given by certain physicists of the rolling of thunder?"

I think both the fact and the inference need reconsideration. For our observations prove to demonstration that air of perfect visual transparency is competent to produce echoes of great intensity and long duration. The subject is worthy of additional illustration. On the

[1] Sir John Herschel gives the following account of Arago's observation: "The rolling of thunder has been attributed to echoes among the clouds; and, if it is considered that a cloud is a collection of particles of water, however minute, in a liquid state, and therefore each individually capable of reflecting sound, there is no reason why very loud sounds should not be reverberated confusedly (like bright lights) from a cloud. And that such is the case has been ascertained by direct observation on the sound of cannon. Messrs. Arago, Matthieu, and Prony, in their experiments on the velocity of sound, observed that under a perfectly clear sky the explosions of their guns were always single and sharp; whereas, when the sky was overcast, and even when a cloud came in sight over any considerable part of the horizon, they were frequently accompanied by a long-continued roll like thunder."—("Essay on Sound," par. 38.) The distant clouds would imply a long interval between sound and echo, but nothing of the kind is reported.

8th of October, as already stated, the siren was established at the South Foreland. I visited the station on that day, and listened to its echoes. They were far more powerful than those of the horn. Like the others, they were perfectly continuous, and faded, as if into distance, gradually away. The direct sound seemed rendered complex and multitudinous by its echoes, which resembled a band of trumpeters first responding close at hand, and then retreating rapidly toward the coast of France. The siren-echoes on that day had 11 seconds', those of the horn 8 seconds' duration.

In the case of the siren, moreover, the reënforcement of the direct sound by its echo was distinct. About a second after the commencement of the siren-blast, the echo struck in as a new sound. This first echo, therefore, must have been flung back by a body of air not more than 600 or 700 feet in thickness. The few detached clouds visible at the time were many miles away, and could clearly have had nothing to do with the effect.

On the 10th of October, I was again at the Foreland, listening to the echoes, with results similar to those just described. On the 15th I had an opportunity of remarking something new concerning them at Dungeness, where a horn, similar to, though not so powerful as, those at the South Foreland, has been mounted. It rotates automatically through an arc of 210°, halting at four different points on the arc and emitting a blast of 6 seconds' duration, these blasts being separated from each other by intervals of silence of 20 seconds.

The new point observed was this: As the horn rotated the echoes were always returned along the line in which the axis of the horn pointed. Standing either behind or in front of the light-house tower, or closing the eyes so as to exclude all knowledge of the position of the horn, the direction of its axis when it sounded could always be inferred from the direction in which the aërial echoes reached the shore. Not only, therefore, is knowledge of *direction* given by a sound, but it may also be given by the aërial echoes of the sound.

On the 17th of October, at about 5 P. M., the air being perfectly free from clouds, we rowed toward the Foreland, landed, and passed over the sea-weed to the base of the cliff. As I reached the base, the position of the Galatea was such that an echo of astonishing intensity was sent back from her side; it came as if from an independent source of sound established on board the steamer. This echo ceased suddenly, leaving the aërial echoes to die gradually into silence.

At the base of the cliff a series of concurrent observations made the duration of the aërial siren-echoes from 13 to 14 seconds.

Lying on the shingle under a projecting roof of chalk, the somewhat enfeebled diffracted sound reached me, and I was able to hear with great distinctness, about a second after the starting of the siren-blast, the echoes striking in and reënforcing the direct sound. The first rush of echoed sound was very powerful, and it came, as usual, from a stratum of air 600 or 700 feet in thickness. On again testing the duration of the echoes, it was found to be from 14 to 15 seconds. The perfect clearness of the afternoon caused me to choose it for the examination of the echoes. It was worth remarking that this was our day of longest echoes, and it was also our day of greatest acoustic transparency, this association suggesting that the duration of the echo is a measure of the atmospheric *depths* from which it comes. On no day, it is to be remembered, was the atmosphere free from invisible acoustic clouds; and on this day, and when their presence did not prevent the direct sound from reaching to a distance of 15 or 16 nautical miles, they were able to send us echoes of 15 seconds' duration.

On various occasions, when fully three miles from the shore, the Foreland bearing north, we have had the distinct echoes of the siren sent back to us from the cloudless *southern* air.

To sum up this question of aërial echoes. The siren sounded three blasts a minute, each of 5 seconds' duration. From the number of days and the number of hours per day during which the instrument was in action, we can infer the number of blasts. They reached nearly 20,000. The blasts of the horns exceeded this number, while hundreds of shots were fired from the guns. Whatever might be the state of the weather, cloudy or serene, stormy or calm, the aërial echoes, though varying in strength and duration from day to day, were never absent; and on many days, "under a perfectly clear sky," they reached, in the case of the siren, an astonishing intensity. It is to these air-echoes and not to cloud-echoes, that the rolling of thunder is to be ascribed.

Experimental Demonstration of Aërial Reflection.—Thus far we have dealt in inference merely, for the interception of sound through aërial reflection has never been experimentally demonstrated; and, indeed, according to Arago's observation, which has hitherto held undisputed possession of the scientific field, it does not sensibly exist. But the strength of science consists in verification, and I was anxious to submit the question of aërial reflection to an experimental test. As in most similar cases, it was not the simplest combinations that were first adopted. Two gases of different densities were to be chosen, and I chose carbonic acid and coal gas. With the aid of my skillful assistant, Mr. John Cottrell, a tunnel was formed, across which five-and-twenty layers of carbonic acid were permitted to fall, and five-and-twenty alternate layers of coal-gas to rise. Sound was sent through this tunnel, making fifty passages from medium to medium in its course. These, I thought, would waste in aërial echoes a sensible portion of sound.

To indicate this waste an objective test was found in a gas-flame brought to the verge of flaring. The action of sonorous vibrations on such a flame was discovered by Professor Le Conte in the United States, who had the sagacity to seize upon the most essential features of the phenomenon. A similar observation was subsequently made by Prof. Barrett, while assistant in the physical laboratory of the Royal Institution; and both he and myself, my present assistant Mr. Cottrell, and Mr. Philip Barry, have succeeded in pushing such flames to an extraordinary degree of sensitiveness. The following brief description of a sensitive flame 24 inches high, issuing from the single orifice of a steatite-burner, is taken from my forthcoming "Lectures on Sound:" "The slightest tap on a distant anvil causes it to fall to 7 inches. When a bunch of keys is shaken, the flame is violently agitated, and emits a loud roar. The dropping of a sixpence into a hand, already containing coin, knocks the flame down. The creaking of boots sets it in violent commotion. The crumpling or tearing of a bit of paper, or the rustle of a silk dress, does the same. Responsive to every tick of a watch held near it, it falls and explodes. The winding up of the watch produces tumult. From a distance of 30 yards we may chirrup to this flame, and cause it to fall and roar. Repeating a passage from the 'Faerie Queene,' the flame sifts and selects the manifold sounds of my voice, noticing some by a slight nod, others by a deeper bow, while to others it responds by violent agitation."

We are now prepared to understand a drawing and description of the apparatus first employed in the demonstration of aërial reflection. I take both drawing and description substantially from an account of the apparatus given by a writer in *Nature*, February 5, 1874:

"A tunnel *t t′* (Fig. 1), 2 inches square, 4 feet 8 inches long, open at both ends, and having a glass front, runs through the box, *a b c d*. The spaces above and below are divided into cells opening into the tunnel by transverse orifices exactly corresponding vertically. Each alternate cell of the upper series—the first, third, fifth, etc.—communicates by a bent tube (*e e e*) with a common upper reservoir (*g*), its counterpart cell in the lower series having a free outlet into the air. In like manner the second, fourth, sixth, etc., of the lower series of cells are connected by bent tubes (*n n n*) with the lower reservoir (*i*), each having its direct passage into the air through the cell immediately above it. The gas-distributors (*g* and *i*) are filled from both ends at the same time, the upper with carbonic-acid gas, the lower with coal-gas, by branches from their respective supply-pipes (*f* and *h*). A well-padded box (*P*) open to the end of the tunnel forms a little cavern, whence the sound-waves are sent forth by an electric bell (dotted in the figure). A few feet from the other end of the tunnel, and in a direct line with it, is a sensitive flame (*k*), provided with a funnel as sound-collector, and guarded from chance currents by a shade.

"The bell was set ringing. The flame, with quick response to each blow of the hammer, emitted a sort of musical roar, shortening and lengthening as the successive sound-pulses reached it. The gases were then admitted. Twenty-five flat jets of coal-gas ascended from the tubes below, and twenty-five cascades of carbonic acid fell from

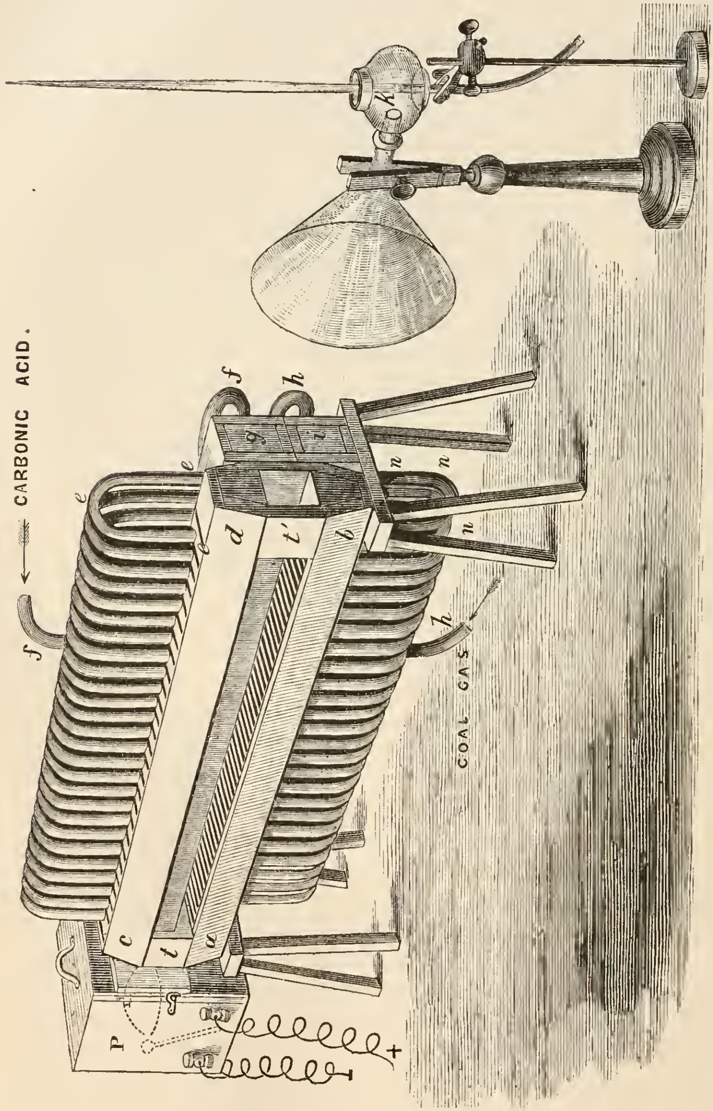

Fig. 1.—Apparatus for showing the Influence of a Non-homogeneous Atmosphere on the Transmission of Sound.

the tubes above. That which was a homogeneous medium, had now fifty limiting surfaces, from each of which a portion of the sound was thrown back. In a few moments these successive reflections became so effective that no sound having sufficient power to affect the flame could pierce the clear, optically-transparent, but acoustically-opaque atmosphere in the tunnel. So long as the gases continued to flow, the flame remained perfectly tranquil. When the supply was cut off, the gases rapidly diffused into the air. The atmosphere of the tunnel became again homogeneous, and therefore acoustically transparent, and the flame responded to each sound-pulse as before."

Not only do gases of different densities act thus upon sound, but atmospheric air in layers of different temperatures does the same. Across a tunnel resembling $t\ t'$, Fig. 1, sixty-six platinum wires were stretched, all of them being in metallic connection. The bell, in its padded box, was placed at one end of the tunnel, and the sensitive flame k, near its flaring point, at the other. When the bell rang, the flame flared. A current from a strong voltaic battery being sent through the platinum wires, they became heated: layers of warm air rose from them through the tunnel, and immediately the agitation of the flame was stilled. On stopping the current, the agitation recommenced. In this experiment the platinum wires had not reached a red heat. Employing half the number and the same battery, they were raised to a red heat, the action in this case upon the sound-waves being also energetic. Employing one-third of the number of wires, and the same strength of battery, the wires were raised to a white heat. Here, also, the flame was immediately rendered tranquil by the stoppage of the sound.

But not only do gases of different densities, and air of different temperatures, act thus upon sound, but air saturated in different degrees with the vapors of volatile liquids can be shown by experiment to produce the same effect. Into the path pursued by the carbonic acid in our first experiment, a flask, which I have frequently employed to charge air with vapor, was introduced. Through a volatile liquid, partially filling the flask, air was forced into the tunnel $t\ t'$, which was thus divided into spaces of air saturated with the vapor, and other spaces in the ordinary condition. The action of such a medium upon the sound-waves issuing from the bell is very energetic, instantly reducing the violently-agitated flame to stillness and steadiness. The removal of the heterogeneous medium restores the noisy flaring of the flame.

A few illustrations of the action of non-homogeneous atmospheres produced by the saturation of layers of air with the vapors of volatile liquids may follow here.

Bisulphide of Carbon.—Flame very sensitive, and noisily responsive to the sound. The action of the non-homogeneous atmosphere was prompt and strong, stilling the agitated flame.

Chloroform.—Flame still very sensitive; action similar to the last.

Iodide of Methyl.—Action prompt and energetic.

Amylene.—Very fine action; a short and violently-agitated flame was immediately rendered tall and quiescent.

Sulphuric Ether.—Action prompt and energetic.

The vapor of water at ordinary temperatures is so small in quantity, and so attenuated, that it requires special precautions to bring out its action. But with such precautions it was found competent to reduce to quiescence the sensitive flame.

As the skill and knowledge of the experimenter augment, he is often able to simplify his experimental combinations. Thus, in the present instance, by the suitable arrangement of the source of sound and the sensitive flame, it was found that not only twenty-five layers, but three or four layers of coal-gas and carbonic acid, sufficed to still the agitated flame. Nay, with improved manipulation the action of a single layer of either gas was rendered perfectly sensible. So also as regards heated layers of air, not only were sixty-six or twenty-two heated platinum wires found sufficient, but the heated air from two or three candle-flames, or even from a single flame, or a heated poker, was found perfectly competent to stop the flame's agitation. The same remark applies to vapors. Three or four layers of air saturated with the vapor of a volatile liquid stilled the flame; and, by improved manipulation, the action of a single saturated layer could be rendered sensible. In all these cases, moreover, a small, high-pitched reed might be substituted for the bell.

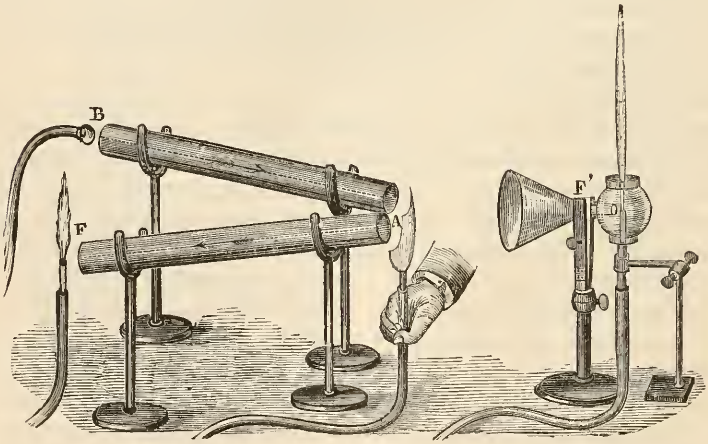

Fig. 2.—Apparatus for illustrating the Reflection of Sound in a Non-homogeneous Atmosphere.

In the experiments at the South Foreland, not only was it proved that the acoustic clouds stopped the sound, but in the proper position the sounds which had been refused transmission were received by reflection. I wished very much to render this echoed sound evident experimentally, and stated to my assistant that we ought to be able to accomplish this. Mr. Cottrell met my desire by the following beautiful experiment, which has been thus described before the Royal Society:

"A vibrating reed *B* (Fig. 2) was placed so as to send sound-waves through a tin tube, 38 inches long, and $1\frac{3}{4}$ inch diameter, in the direction *B A*, the action of the sound being rendered manifest by its causing a sensitive flame placed at *F″* to become violently agitated.

"The invisible heated layer immediately above the luminous portion of an ignited coal-gas flame, issuing from an ordinary bat's-wing burner, was allowed to stream upward across the end *A* of the tin tube. A portion of the sound issuing from the tube was reflected at the limiting surfaces of the heated layer, the part transmitted being now only competent to slightly agitate the sensitive flame at *F′*.

"The heated layer was then placed at such an angle that the reflected portion of the sound was sent through a second tin tube, *A F* (of the same dimensions as *B A*). Its action was rendered visible by causing a second sensitive flame placed at the end of the tube *F* to become violently affected. This *echo* continued active so long as the heated layer intervened; but upon its withdrawal the sensitive flame placed at *F′*, receiving the whole of the direct pulse, became again violently agitated, and at the same moment the sensitive flame at *F*, ceasing to be affected by the echo, resumed its former tranquillity.

"Exactly the same action takes place when the luminous portion of a gas-flame is made the reflecting layer, but in the experiments above described the invisible layer above the flame only was used. By proper adjustment of the pressure of gas, the flame at *F′* can be rendered so moderately sensitive to the direct sound-wave that the portion transmitted through the reflecting layer shall be incompetent to affect the flame. Then by the introduction and withdrawal of the bat's-wing flame the two sensitive flames can be rendered alternately quiescent and strongly agitated.

"An illustration is here afforded of the perfect analogy between light and sound; for if a beam of light be projected from *B* to *F′*, and a plate of glass be introduced at *A* in the exact position of the reflecting layer of gas, the beam will be divided, one portion being reflected in the direction *A F*, and the other portion transmitted through the glass toward *F′*, exactly as the sound-wave is divided into a reflected and transmitted portion by the layer of heated gas or flame."

Thus far, therefore, we have placed our subject in the firm grasp of experiment; nor shall we find this test failing us further on.—*Contemporary Review.*

THE MENTAL ASPECTS OF ORDINARY DISEASE.[1]

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SO long as the mind was regarded as something separated from the body, or only united to it by feeble ties, bodily conditions could have nothing to do with mental phenomena—insanity was a disease of the soul. The monk, standing over a miserable lunatic chained to a staple in the wall, and flogging him in order to make him cast his devil out, was a logical outcome of this hypothesis. The union of psychology and physiology is the closing of the circuit, in one direction, of the pursuit after knowledge, and marks the initiation of a rational comprehension of the mind and of its relation to corporeal conditions. How such mistaken ideas of the word *melancholia*, as those entertained by the monk in his capacity of physician for diseases of the mind, could have attained their sway in the face of the maxim *mens sana in corpore sano*, only becomes intelligible when we remember the ignorance, the superstitious prejudices, the contempt for knowledge of the natural man, which found their highest expression during the monkish supremacy of the dark ages. Slowly but surely was the emancipation of the intellect from the fetters of priestly tyranny achieved. The days of the minor Trinity—the soul, the mind, and the body—are numbered; the advent of a physiological psychology is at hand. That insanity which was regarded as an indication of some disease of the soul, in whose production the body had no share, is now known to be linked with appreciable pathological changes, and in many instances is amenable to physical remedial agents. Thought is the product of the cells of the gray matter of the brain—the result of a change of form in inorganic matter taken into the system as food, of which acids and other products of oxidation, of retrograde tissue-metamorphosis, are the waste.

Such being the case, it is obvious, then, that bodily conditions will affect the nutrition of the brain, or rather of the cerebral cells, and so modify their products. It is not necessary to go into the more pronounced conditions called insanity for the evidences of such influence; they are to be found in the varying mental attitudes of common life. It is true, however, that the study of the more marked cases furnished by insanity, with their deeper shadows and clearer definitions, is the best preparation for the proper recognition and discrimination of the finer shades, the slighter changes, which exist among the sane. More especially is this the case in attempting to analyze the varying emotions. At one time all looks bright, cheerful, and encouraging; at another, the same prospect looks cheerless and tinted with despair.

[1] Condensed from the *Journal of Mental Science*.

This change depends upon physical conditions, and a more pronounced physical state not only involves the emotional centres, but implicates the intellectual processes. Thus, a slight amount of bile in the blood, or an excess of renal products, may depress a man with hopeless despair or drive him into paroxysms of violent passion. The delirium of fever is a familiar instance of the influence exercised by passing bodily conditions upon the brain and its product—thought.

When the nutrition of the brain is good, we experience an agreeable sense of well-being, which shows itself distinctly in after-dinner geniality. When the nutrition is imperfect, or the arterial blood is of abnormal composition, the consequences are a mixture of irritability and bad temper, blended with depression. We are all familiar with the crossness of the hungry man; when fasting, crossness is interchangeable with hunger—is often its substitute, and forms a contrast with the amiability of repletion. Especially is this irritability seen in those whose digestive powers are weak. A similar irritability is the ordinary mental attitude of convalescence from acute disease, and either precedes or runs into and coexists with the keen appetite usually found at that time. They are linked together by something more positive than coincidence.

The dependence of modifications of the functional activity of the cerebral cells upon other corporeal conditions than changes in the blood is now well recognized. There are communicating fibres by which the brain receives impressions of varying character from different organs. An impression coming in from some far-away point stimulates or inhibits the action of the cerebral cells. So strong may be the impression that actual insanity may result, as in the case, related by Schroeder van der Kolk, of a lady who became insane whenever her womb became displaced, and sane again as soon as it was returned to its place.

The effect of several morbid states is to stimulate the brain into greater activity. A non-medical but most acute observer and able writer [1] says:

"It seems even that bodily pain and disease are not only compatible with, but may directly contribute to, the loftiest efforts of the intellect. They sometimes positively enhance its powers. The effect of some disorders and of certain sorts of pain upon the nerves is to produce a cerebral excitation; and the stimulus thus communicated to the material organ of thought renders it for the time capable of unusual effort. Men under the stirring influence of severe pain are capable of a degree of imaginative and ratiocinative brilliancy which astonishes themselves and all who have known them only in ordinary moods of comfort. Torpid faculties become vigorous and sparkling. Forgotten knowledge is recovered. Marvelous gleams of insight are vouchsafed them. The wonderful eloquence of Robert Hall was doubtless greatly owing to the stimulating influence of a terrible spinal malady. Dr. Conolly mentions a gentleman whose mental faculties never reached their full power except under the irritation of a blister. Ab-

[1] "The Enigmas of Life," by W. R. Greg.

normal and unsound conditions of the bodily organs sometimes give us glimpses of mental powers and possibilities far exceeding any thing of which ordinary health is capable. The phenomena of some nervous disorders are positive revelations, and most startling ones, of what the human intellect, disengaged from matter or under favorable material conditions, might achieve and learn."

When Greg talks of intellect disengaged from matter, he is led away into poetical metaphor, which is, however, allowable in one who is not a professed physiologist.

We are all familiar with the effects of alcohol upon the intellectual powers. A gentleman mentioned by Dr. Willis, who was liable to periodical attacks of insanity, said that he expected the paroxysms with impatience, because, during them, he enjoyed a high degree of pleasure. "Every thing appeared easy to me. No obstacles presented themselves either in theory or practice. My memory suddenly acquired a singular degree of perfection. Long passages of Latin authors occurred to my mind. In general, I have great difficulty in finding rhythmical terminations, but then I could write verse with as great facility as prose."

There are two distinct physical conditions under which the intellect seems to possess a power and a brilliancy much exceeding the normal standard. These two conditions are: 1. The initial or pre-tubercular stage of pulmonary phthisis; and, 2. The condition of chronic gout. Whatever difference of opinion may exist as to the explanation of the cause of this high state of mental activity, there can be none as to the fact. There is, as it were, almost an aureole of intellectual light around the heads of those who are about to enter the fated pathway of pulmonary tuberculosis. To what it is due, it is difficult to say. One factor may be some accession of arterial blood to the cerebral cells in excess of the normal flow. We know that there are usually an accelerated pulse-rate and a heightened temperament in such cases. There may be some nerve-communication between the lungs and the vaso-motor nerves of the cerebral vessels, of which we are as yet but dimly conscious, which may some day explain the matter to us. As to the intellectual power of the gouty, there is less difficulty in explaining it. In the first place, the blood of the gouty is highly charged with nitrogenized matter. Carpenter has pointed out ("Human Physiology," sec. 62) how desirable a nitrogenized diet is for the evolution of nerve-force, while Liebig dilates upon the effect of food upon the disposition, in his well-known "Letters on Chemistry." M. Metz, of Mattray, found the value of a liberal dietary in giving strength of will to irresolute boys in his reformatory. An excess of nitrogen in the system, and especially in the blood, acts as a stimulant to the brain-cells in the case of the gouty. This, however, is but half of the matter; there is an equally, or even more important factor, in the condition of the circulation.

Careful investigation has demonstrated to us the state of the circulation in chronic renal inadequacy. There is usually decided hypertrophy of the left ventricle, and a high arterial tension, originating in a contracted condition of the terminal arteries. As a consequence of this tension, the blood-pressure on the brain is well sustained; and a free supply of arterial blood, rendered perhaps more than ordinarily stimulating by the presence of nitrogen in excess, evokes a heightened activity of the cerebral cells. Simple hypertrophy of the heart is mostly found in the subjects of chronic renal changes. That there is a certain explosiveness in the gouty, together with much mental activity, is simply a clinical fact. The excess of nitrogen in the blood stands in a suggestive relationship to the explosive irritability, while the high blood-pressure is evidently causally related to the heightened mental activity. The two factors requisite for rapid evolution and discharge of force by the cerebral cells are found together under the above-named combination. If the changes in the circulation are imperfect, and the blood-pressure is but low, or even normal, the gouty person is not mentally inactive, but is despondent.

Bichat observed that the length of the neck exercises an influence over the mental activity of the individual. Persons with short necks have a better sustained power of work than those who have long necks, or, in other words, other things being equal, the brain, which is superimposed on a short neck, has an advantage over the brain fed by a long carotid artery. Van der Kolk is in agreement with Bichat upon this point. An extensive series of observations inclines me to agree with them.

Van der Kolk also quotes from Haller the observation that rickety children have generally large heads, and possess quick perceptive faculties; and that the blood-vessels of their heads are distinguished for their large calibre. Certainly such children are commonly very precocious. There is a point, however, in relation to this matter which must not be overlooked. Rickety children are usually of scrofulous tendency, and in the scrofulous there is usually an excess of lithates in the blood, which will not be without the ordinary effect exercised by nitrogen on the brain. The great Dutchman also states, "It is a known fact that hunchbacked individuals, in whom the blood flows more quickly and strongly toward the brain, are remarkable for vivacity of spirit." It will not do, in this consideration, to leave out of the question the possibility of a mental factor; that the physical deformity turns the mind of the individual toward mental cultivation as a compensation for bodily defects. Granting this, we must also remember that mere will and perseverance exercise a limited influence, and only permit a brain to make the most of itself. What exists there potentially, it may draw out into actual manifestation; but with this the power of the will ceases. An effort of the will may and does dilate the blood-vessels of the brain, and permits larger circulation through it; but the general blood-pressure in the systematic vessels is an important matter in sustaining the intercranial flow. If the general blood-pressure in the vessels of the head and neck is high and well maintained, then a brain can work up to a much higher power, just as a steam-engine may be worked up to a higher pressure, and so become actually more powerful.

While we recognize the fact that mental conditions are causally associated with the amount of the blood-supply, indeed to a great extent rest upon it, it must not be supposed that I wish to under-estimate the importance of the condition of the cerebral cells themselves, either as to their inherited peculiarities, or as to the conditions produced by the experience of the individual. Such consideration is, however, without the sphere of the present paper, which deals with cerebral manifestations in relation to ordinary disease, and not with those ailments which belong to the province of the alienist physician. To one form of disorder of the cerebral cells alone may reference be made here, and that is as to the effects of mental over-strain. Brain-tissue can be developed by exercise, and worn out by overwork. When this latter condition has been induced, there exists that irritability which forms part of the early stage of the exhaustion of nerve-matter. In all overtried brains there is much irritability and tendency to manifest what we term temper. This fact we learn in time about the individual, but we are somewhat slow to recognize it in the abstract. It is socially desirable and important that such recognition be more general.

In considering the associations existing between cerebral manifestations and certain conditions of the organism, and the effect exercised by the latter upon the former, it is important to bear in mind that the brain is divided into two vascular areas: 1. The anterior, fed by the internal carotids; and, 2. The posterior, fed by the basilar artery; nor is the amount of inosculation in the intercranial circulation such as would allow vicarious action to make good a deficiency caused by an interference with the direct supply of either area. These two vascular areas contain brain-cells with different properties and functions. There is much reason to believe that the emotions and systematic sensations lie on the posterior area; and that the intellectual and motor powers, together with general peripheral sensations, lie on the anterior area. In other words, the posterior area is associated with the organic processes of the system; the anterior with the animal life—with the relation of the organism to its surroundings. The vaso-motor nerves of these two areas are differently derived. The nerves of the cerebral arteries spring from the lower ganglion of the great sympathetic nerve in the neck, into which run the fibres ascending from the abdomen; while the carotid arteries derive their vaso-motor supply from the middle and upper ganglia. Thus we can see how the emotions sympathize with the organic processes, especially those located in the abdomen, and so can see melancholia in a new light; can comprehend how mental depression may wait upon and depart with abdominal disturbance. The disturbance does not extend to the intellectual processes; the emotions alone are involved. The sense of well-being, or of discomfort, depending upon systemic conditions, tells of the relation existing between the emotions and the organic processes; and the nerve-tracks just described enable us to comprehend the subject more clearly.

There is an interesting point connected with this division of the cerebral hemispheres, and the functions of each division, to which we may advert. It is the association existing between states of emotional depression and abdominal disease, and the comparative absence of such depression in affections of the lungs. Marshall Hall writes: "The temper of the patient is singularly modified by different disorders and diseases. The state of despondency in cases of indigestion forms a remarkable contrast with that of hopefulness in phthisis pulmonalis, and other serious organic diseases."

In diseases of the lungs, the condition of depression is rarely present, and, when so present, is possibly due to some abdominal complication; though, of course, some of the existing depression may be fairly attributed to the anxiety naturally arising from an intelligent comprehension of the danger impending. In tuberculosis of the lung there is commonly such an emotional attitude in the patient as has earned for itself the designation of *spes phthisica*. Here the hopefulness is as irrational as is the depression of some other affections. The consumptive patient just dropping into the grave will indulge in plans stretching far into the future, ignoring his real condition, and the impossibility of any such survival as he is calculating upon. It is a curious yet a familiar state. Hope seems to rise above the intelligence, just as in certain abdominal diseases there is a depression which defies its corrections. The intellect is not equal to finding the true bearings or of correcting the exalted emotional centres. In curious relation to these conditions stand well-known differences of the pulse. In chest-diseases the pulse is usually full, sometimes bounding; in abdominal disease it is small and often thready. The pulse of pneumonia and the pulse of peritonitis are distinctly dissimilar and contrast with each other. It is well known that there is much more tendency to collapse in abdominal than in thoracic disease; taking the conditions of the pulse together with the emotional attitudes of these affections, the synthesis is unavoidable that some effect is produced by the tubercular disease in the lungs upon the emotional centres as opposite to the effect of abdominal disease as are the varied effects upon the pulse; and further that the result is probably produced through the circulation. The explanation which is shadowed out, for it really does not amount to more, is that abdominal disease causes a depletion of the emotional centres—of which depression is the outward indication—while phthisis leads to a plethoric state associated with exalted emotional conditions. In either case the intellectual and volitional centres appear unequal to the task of maintaining the balance which normally exists. As a matter of fact, there are certain mental attitudes found in some diseases which are so regularly present, so well marked and pronounced, that they may fairly be included as a part of the rational symptoms. So commonly is mental depression found along with biliary disturbance that the name *melancholia* was given to these conditions of mental gloom; and modern observation is but establishing the propriety of the term.

Allied in essence to melancholia is the panphobia, or "low spirits," common to women generally, but especially found in the *habitués* of our out-patients' rooms. It is the cry of the suffering brain for better nutrition, for a more liberal supply of arterial blood. There is much emotional mobility and the patient is easily moved to a flood of tears by the slightest exciting cause. Under different circumstances relief from the depression is sought in alcohol, and this is the most depraved, the most hopeless, and the deadliest of all forms of habitual intoxication, the more hopeless from its being based on physical conditions; or it stimulates the spinster and the widow to a pseudo-religious existence, where the religious fervor is the measure of the cravings of the ungratified physiological aspirations.

We do not consider, perhaps, because the subject is repugnant to us, how much our psychical attitude, even to religious, the highest of all thought, is based upon conditions of the body; that body which theologians of the old school denominate vile, which they would trample under foot, nay, even ignore, yet which is reigning supreme and dominating and directing them in their highest aspirations. What a terrible revelation this gives us of the psychological attitude of the monk, who thought to subdue his inborn passions by scourgings, fastings, sleeplessness, and religious exercises, when all the while he was the victim of their thwarted and riotous activity as they crowded his mental horizon with gloomy or sensual images and presented a future of everlasting damnation to his superstitious vision!

Another form of psychical disturbance is furnished by the perturbations termed hysterical attacks, and which usually occur under circumstances of repressed passion. There are an excitability and mobility about the person which tell how the emotional centres are quivering and vibrating under the tension to which they are subjected, and the emotional oscillations, from weeping to laughing, indicate that the emotions are no longer under the control of the volitional centres. This loss of equilibrium becomes more marked when any disturbance of the bodily health leaves the organism at the mercy of these emotional storms. Hysterical attacks are generally explosive discharges of the emotional centres, as epilepsy is of the motor or mania transitoria (demoniacal possession) is of the volitional centres. They all resemble the "blowing of the engine" when it has stood still some time and the steam-pressure is becoming dangerously high.

Much mental instability is found among sufferers from chronic heart-disease, and many and pronounced are the mental modifications induced. In one case, I remember well, a very old patient, who was the subject of aortic obstruction, became remarkably polite when the results of the cardiac lesion were very marked, a mental attitude far removed from that which he habitually assumed. Usually a totally opposite character of change is produced, and the effect is to cause the mental operations to be imperfect, unsustained and unequal, while there are present suspicion, doubtfulness, vacillation, and caprice. Indeed, the mental change is usually for the worse; and along with intellectual enfeeblement there is an alteration of the emotional products which we have seen to be allied with cerebral depletion. The false and morbid feelings which are the products of imperfectly nourished cerebral centres bear the same relation to normal thought that Emerson says evil does to good—it is good in the making; and more perfect elaboration of the outcomes of emotional centres would give us healthy instead of morbid feeling.

The mental attitude of sufferers from heart-disease is usually one of caprice, unsustained volition, together with suspiciousness and groundless fear—imperfect emotional products.

Another marked mental attitude is furnished by those who suffer from gout in any of its forms, for suppressed gout is the most protean of diseases. We have already seen how gout-poison stimulates the intellect in the earlier stages of granular kidney; what we may now consider is the mental modification produced by advanced disease. There is a mixture of explosiveness, the gouty temper, with suspicion and depression, the consequences of spasm of the intra-cranial arteries. Instead of the well-sustained blood-pressure of the early stages with the stimulant gout-poison irritating the cerebral cells into activity, we have the stimulant quality of the blood together with an impaired and insufficient supply. The resultant product is a blended compound of irritability and suspicion, bad temper and anxiety, the latter all the more aggravating from a consciousness that it is not mere illusion, but an emotional hallucination.

Such individuals are the terror of their dependents and the *bêtes noires* of their domestics. There is such a villainous state of temper, at times ascending to ferocity, that the person becomes simply intolerable; the unfortunate sufferers themselves being still further tortured by the haunting impression that they are utterly unreasonable, and that their attitude does not arise from any provocation from without, but that it takes its origin in some abnormal condition existing within. In one case well known to me the sufferer sought relief in religious exercises, in resort to her Bible and to prayer—it is needless to say without the desired result. What she needed was not spiritual discipline, not correction of the mind through the soul's portals, for she was a truly good and high-minded woman, but a remedying of the bodily condition on which the mental state causally depended. As a matter of fact, well-directed treatment produced a restoration of the normal feelings and emotions which all the spiritual exercises had signally failed to achieve.

Another peculiar and fairly-pronounced mental attitude is that furnished by the victim of cancer. The form assumed here is that of sullen and defiant submission to the inevitable. There is rarely any active and positive attempt made by the sufferers themselves to avert their doom. There is, as it were, a volitional control exercised over the impulses, which is marked, and the sufferer submits to a grip he sees no chance of eluding. But it must not be supposed that there is an abolition of the instinct of self-preservation; it is merely subordinated. That this is the actual attitude is shown by the fact that when the mind is wandering at the last, especially in gastric cancer, which interferes so much with nutrition, the patients in their delirium commonly ask for a knife in order to excise the hostile malignant growth which is involving their existence.

The mental attitude of pyæmia (alteration of the blood by pus) is, again, quite distinct from any of the foregoing. It is that of absolute indifference. From the first long shivering fit which marks the initiation of the fateful disease, the mental attitude is usually that of imperturbable indifference. Marked by utter unconcern as to the course of the disease, it contrasts very strikingly with the ill-founded hopefulness of hectic, and especially of pulmonary phthisis. Of course it is not asserted that the mental attitudes described are invariable and ever present in the different diseases; only that they are so common that they cannot be regarded as mere coincidences.

In diabetes mellitus, too, there is a condition of mental languor and depression, which is as marked as the muscular lethargy and lassitude manifested by sufferers from that affection, and which often precedes those physical symptoms which we are too much inclined to regard as the chief indications of that disease.

The condition of the mind in the delirium of fever is a subject of much interest, albeit it is surrounded by many difficulties. The great one is that people at large are too much accustomed and inclined to regard delirium as aimless, objectless mental action—a chaos of broken ideas and unconnected thoughts, or an uncovering of the sewers of the mind, the revealing of secrets not always innocent. The first is the way in which they regard it in others, the latter, the form in which they apprehend it in themselves, so that there is not given to it that intelligent attention the subject deserves; nor are those immediately and constantly around the delirious patient likely to possess a calm, dispassionate, and competent capacity to attend to what is going on in his mind, so far as it finds expression in words. The anxious relatives and the overworked paid nurse do not possess the qualities requisite for correct observation of this complex condition, even if they could be induced to make the nature of the delirium the object of their attention. The impressions remaining on my own mind of my thoughts during a pretty sharp and well-sustained delirium, due to a grave attack of scarlatina, are that there were two leading ideas dominant in my mind: the one in relation to my surroundings, the other in relation to my aims and my occupation. The first, though less predominant, were distinctly the more vivid impressions, and they were not only very unpleasant, but their remembrance is ineffaceable. They arose chiefly through the weakened senses, especially the sense of sight. The bedroom I had occupied for years had been rearranged to adapt it to the necessities of a sick-room, and, on waking, the eye did not immediately recognize it. This at once gave a direction to the wandering thoughts, and the leading idea was to get home. The opposition offered to my attempt to escape seemed to me so unjust and improper that violence must be resorted to in order to overcome it, and then followed a wild, delirious struggle, terminating in complete exhaustion. This opposition engendered a strong feeling of personal dislike, blended with suspicion toward those around me, and their kind attentions were interpreted by the reeling brain as unjustifiable interference with natural and intelligible wishes. The remembrance of the feeling of dislike thus originated remains sufficiently strong to occasionally tint the thought yet; for the residua remaining in the cerebral cells exercise an influence on the thought-currents when passing over them.

The other source of disturbance was the influence of the lines of thought which were predominant in the mind ordinarily. These formed the chief subject of my wanderings during the delirious period. At times, the impression that certain patients ought to be seen would become so vivid that I desired to be dressed in order to pay the required visits. Opposition to this, of course, aroused indignation and resentment, and strengthened the suspicions already excited by the restraint exercised to prevent, as I imagined, my returning home.

The remembrance of the condition is still sufficiently vivid to explain the mental attitude of those whose intellect is waning, either from dotage or from a like condition of brain-failure inaugurated by acute disease. Why their relations, who attempt to contradict or to control them—not always with the happiest tact—are objects of dislike and suspicion, is intelligible enough; as also why attendants who humor and cajole them are thereby endowed with a potential, undue influence. The brain, becoming less and less functionally capable, is more and more unequal to the correction of its ill-founded or unjust dislike.

There is nothing monstrous in the mental products; there is just that deviation from the rule that might be anticipated when the functional activity is modified by structural changes. There is not a new line of thought instituted, leading in opposite directions to the normal thought, but a misdirection of the ordinary mental processes. There is, however, a certain amount of illusion which, when pronounced, or when the effect upon the brain-cells is such as to cause an evolution of distinctly-erroneous thought, or actual hallucinations, indicates that the frontier of sanity is crossed.

Such considerations will enable us to observe and to comprehend that initiatory stage of mental impairment which precedes obvious and well-marked dotage. The earlier stages, the lighter shades of mental failure, of waning brain-power, are distinct enough to the trained eye, long before those more obvious changes are reached which are recognized by the untrained observer. Such mental changes are commonly found in those undergoing degenerative physical changes, not only in the very aged, but in those passing into premature decay; in fact, mental impairment and decay are but the evidences or outcomes of the implications of brain-tissue in the general degeneration. We are, of course, most familiar with such changes in the very old, in whom we regard them as almost normal. The mental grasp is imperfect and illusive; petulance and caprice are the characteristics, especially of those in whom the intellect was never very strong. Their intellectual vision is deceptive and untrustworthy. A dim consciousness of some such change obtains in the mind, and makes them deeply suspicious and extremely susceptible, and ready to take offense at the slightest indication by others of a knowledge of their growing incapacity. Nor can we feel surprised at this sensitive suspiciousness. Mental decay cannot be a pleasant matter for those undergoing it, and no wonder they are excessively jealous of any alteration of manner or attitude.

A similar condition of enfeeblement, combined with excessive jealousy and deep-rooted suspicion, is furnished by those who have anticipated the normal time of senile decay by habits of drunkenness. The man who is beginning to yield under persistent alcoholization, and who feels that his powers are giving way, is generally suspicious and jealous, if not actually malicious. The intellect undergoing premature degeneracy is more readily and easily provoked than is that of a person entering normal dotage; while there is often coexistent a certain amount of spasmodic vigor of temporary active irritability. Such persons are simply dangerous to those dependent upon them, and not to be trusted—their mischievousness being only restrained by their incapacity to execute or put in force their malicious designs.

There are two other mental attitudes which are not directly associated with bodily disease, but which exercise so distinct an influence over physical conditions, especially in sickness, that they may not improperly be considered here, though not quite falling within the scope of this paper. One is that condition of mental impairment in which the intellect becomes servile. It is usually shown by elderly people, who are utterly dependent on the bounty, and therefore on the will, of others. That such a condition of helpless submission should obtain under these circumstances, and especially in women, is readily to be conceived. The utter helplessness and entire abolition of self-confidence so induced have a most pernicious effect upon the mental processes; the intellect becomes restricted, and solely directed toward observing and accommodating themselves to the varying moods and passing caprices of those upon whom they depend. Chameleon-like, they change color with every new shade of opinion with which they come in contact, until at last they lose their individuality altogether. The mental condition of these unhappy beings is pitiable in the extreme; there is a paralysis of all volition. "Everywhere and ever, to be weak is to be miserable," and cunning is the only refuge of the feeble. This mental attitude is a matter of moment, and needs recognition when such persons become objects of medical care, and must be included in the formation of a prognosis; the mental instability and tendency to oscillate being very troublesome, and interfering with the working of every systematic plan. Under totally different circumstances, a similar brain-starvation is manifested by those persons who voluntarily cultivate a mental predisposition to religio-melancholia. Their aspirations, originally directed by their surroundings, are ultimately guided by an artificial substitute for the will which they in time develop. It is the psychical side of a question of which the physical side has been discussed before. The intellectual imbecility eventually reached under these circumstances is something pitiable. The intellect is prostrated before an irritable conscience, rendered morbidly sensitive by persistent self-introspection fostered by vigils, developed by fasting, and misdirected by a cramped and imperfect education. The influence exercised by this condition of intellectual enfeeblement also becomes practically important when any line of treatment has to be pursued, and especially so in that complex combination of dyspepsia and constipation to which such persons are so subject. With such persons, the plainest and simplest truths of the natural man seem to take on the aspect of most abstruse and difficult problems; the fullest explanations and clearest directions are insufficient to enable their enfeebled intellects to grasp the subject. Superstitious credulity displaces reasonable belief, and enervates the mind until it can evolve no healthful thought; the morbid activity of pseudo-religious sentiments induces such a palsy of the moral nature, that it becomes incapable of rising in revolt or of seeking to escape its intellectual thraldom.

In those who are exhausted and worn out by toil, either mental or physical, or both combined, but usually by strenuous bodily labor, united with petty mental anxieties and fretting, wearing thought, a condition of brain-degeneration is produced, which exercises much effect upon the progress of any ailment requiring medical treatment. This class of cases occupies a sort of disputable ground, a border territory which scarcely permits of their being included in hand-books of insanity, nor yet in the ordinary systems of medicine. They are considered here among the aspects—not as outcomes of disease, as are the mental attitudes described in the earlier divisions of this paper, but rather as mental conditions, not normal nor yet insane, which exercise much influence over the progress and course of ordinary ailments.

Finally, there is a condition of temporary, evanescent brain-impairment, which is produced by acute disease, and especially by severe attacks of fever. The mental faculties are usually somewhat impaired by severe attacks of typhoid fever, and soldiers, after recovery from such, are not put on sentry duty for months, as they are pretty certain to forget the watchword and countersign. At other times, more marked impressions are made; certain acquirements are entirely lost, or the mind may even become a smoothed tablet. Many curious instances of such effects are furnished by Abercrombie, in his well-known work, "The Intellectual Powers," and by Carpenter, in his recent work on "Mental Physiology." Commonly enough, this passing condition of brain-impairment is followed by an accession of mental vigor and a condition of intellectual activity which remain permanently and exercise an excellent influence over the after-life of the individual.

The relations of body and mind are becoming much more comprehensible and better understood since Science has shaken off the incubus of theological teaching as to the severance of soul and body; that baneful psychology is now thoroughly undermined; the erroneous and mischievous superstructure is cracking and gaping on every side, and ere long the ground occupied by a crumbling ruin will be covered by a gradually growing erection, based on a foundation of facts, and reared by an expanding intelligence.

BIOLOGY FOR YOUNG BEGINNERS.[1]

By SARAH HACKETT STEVENSON.

II.

IN the chimney-corner by the kitchen-fire stood a quaint stone jar that every winter morning bubbled over with the light, gray foam of buckwheat-cakes. While our "mouths watered," our minds wondered—wondered at the magic by which so many cakes were made out of so little flour. We believed there were fairies in the yeast; but it was only the other day that I succeeded in finding these fairies, and I want to tell you how you may find them too.

[1] From "Boys and Girls in Biology," in the press of D. Appleton & Co.

To begin with, you must have a spoonful or two of yeast to look at while I talk. You will probably notice first a number of bubbles, like soap-bubbles; but, instead of common air, the yeast-bubbles contain a gas made by the yeast—carbonic-acid gas. Next you will notice the brownish color of the yeast; it grows thicker and muddy, and after an hour or so begins to rise. This rising the chemists call fermentation; biologists call it growing. The spoonful has become a cupful. The yeast is really alive, and it is one of the simplest forms of life. In studying biology, then, or the science of life, we begin at what seems the beginning.

All that I have described you can see with your own eyes; but now I must tell you something about the yeast which you could never find out with your eyes alone. With the aid of the microscope, a great many little solid bodies are seen floating about in it. Sometimes they are found alone, but most frequently in groups (Figs. 1–5),

Fig. 1.—Round Cells.

Fig. 2.—Lemon-shaped Cells.

Fig. 3.—Outer and Inner Surface of Sac.

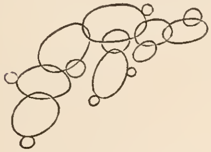


Fig. 4.—Group of Cells.

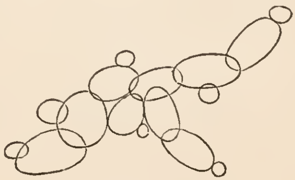


Fig. 5.—Group of Cells.

and each one is about $\frac{1}{3000}$ of an inch in size. Though they are solid, yet we can see through them, and they are always round (Fig. 1), some of them not quite as round as a ball, more like a lemon (Fig. 2), but none of them are square or flat. The cover of each one is double (Fig. 3), that is, it has an outside and an inside. Under the microscope, these two surfaces look like two round lines, one within the other (Fig. 6). Inside these lines is something which looks like little grains (Fig. 7); and this whole cover, with all that is inside of

Fig. 6.

Fig. 7.

Fig. 8.

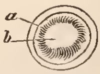


Fig. 9.—Yeast-cell, or Torula.
a, Jelly, or Protoplasm;
b, Thin Space, or Vacuole.

it, is called a cell. Now you must learn of what these cells are made. First there is the outside part, which is like a bag or sac. This bag is tough and solid, and is full of a jelly-like substance, which is thick and brownish, next the wall of the bag, but thinner and more transparent toward the centre (Fig. 8). This jelly (*a*) is called protoplasm, and the thin space (*b*) in the centre is an air-cell or vacuole (Fig. 9). If you color the yeast-cells, you can see the different parts much better. A drop of magenta will pass right through the sac without staining it at all. The cell-jelly, or protoplasm, will be quite red, and the vacuole will not be colored, though it may look pinkish, because you see it through a layer of the protoplasm (Figs. 10, 11). Now, if the cell were all made of the same material, it would probably all be colored by the magenta.

These cells are called torulæ—a single one is a torula. The word means a little knobby swelling. You will soon see how it comes to

Fig. 10.—Jelly stained, and the Sac clear.

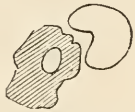


Fig. 11.—Broken Cell. Sac clear, Jelly stained.

have this name. If you have followed me carefully, better still if you have seen it all for yourselves under the microscope, you know that the torulæ are alive, and that they grow. Every thing that grows must have food. Now, whence does the torula get its food? From the liquid in which it floats. What is this liquid? The greater part is water, but if you sow yeast in pure water it will hardly grow at all; but if you put in ever so little sugar, it will froth and bubble considerably. If besides the sugar you give it the least bit of ammonia, magnesia, lime, and potash,[1] it will thrive splendidly. The torula takes in this food, and churns it up into that "elixir of life" or protein, woody cells or cellulose, and fat. Then, if you watch carefully, you will see a whole lot of little buds coming out around the edges of the wall (Fig. 12); hence the torula is really a little knobby swelling. Some of the buds have other buds at their edges; all these buds are the little baby-torulæ. By-and-by they break away from the old mother-torula, but they always pay visits back and forth, and sometimes build their houses right next the parental roof in clusters (Fig. 13); at other times they build in long rows, like a chain or a string of beads (Fig. 14). Of this you may be sure, every torula has a mother. People have been trying to prove for two hundred years or more that these little specks of life can make themselves. Some time

[1] PASTEUR'S FLUID.

	Parts.		Parts.
Potassium phosphate	20	Cane-sugar	1,500
Calcium phosphate	2	Water	8,376
Magnesium sulphate	2		
Ammonium tartrate	100		10,000

I will tell you how you can prove that this is not true. These little torulæ float about in the air, or sleep in any dry place, never showing that they are alive till they are planted in some nest or nidus. When the cook dries her yeast-cakes, she puts all the little torulæ to sleep, and there they go into winter quarters, or hibernate in their cells, like the bears in their caves.

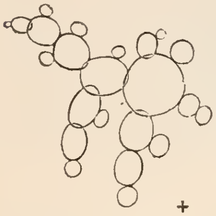


Fig. 12.—Cell and its Buds.

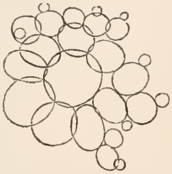


Fig. 13.—The Baby Torulæ grouped around their Mother.

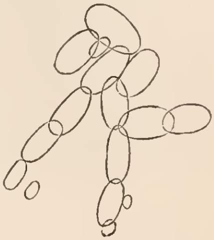


Fig. 14.—Cells linked together in Chains.

There is still another appearance of yeast. Let your cup of yeast stand long enough, and do not add any more sugar or water to it, you will find that the bubbling or fermentation stops, the torulæ settle to the bottom, and the fluid comes to the top. This fluid has a strong or biting instead of a sweet taste, like the fluid into which you first placed the yeast. The fermentation has changed its nature—the fairy torulæ with their magic wands have turned the sugar into carbonic acid, alcohol, glycerine, and succinic acid. These are called the products of fermentation. The carbonic acid, you know, passed off through the bubbles, the other products are still in the fluid. A little of this fluid will make you merry; if you take much of it, you will become intoxicated. This is due to the alcohol, and the value of yeast depends upon its power to make alcohol. You may know that the fluid is alcohol if, when you touch it with a lighted match, it burns with a blue flame.

Now, I have told you the torula grows—it has life; but how does it grow—as a mineral, a vegetable, or an animal? The mineral grows larger and larger by additions made to its outside. This is called growth by accretion. But the torula or yeast-cell grows by taking in new substance in among the particles of its old substance, and this kind of growth is called by a long name—intussusception. This is one of the reasons why it is not a mineral. Is it an animal? The line that divides the animal from the vegetable kingdom is not very well marked, but there are two reasons why the torula is not an animal. In the first place, its jelly or protoplasm is shut up in a close sac, but the protoplasm-jelly of animal cells forms a wall of itself. In the second place, the torula can make its own food or protein out of the raw material it finds in the liquid, while the animal cells seem to have no such power; they must have their protein already made, and their work is to destroy it. So, if the torula is not a mineral nor an animal, it must be a vegetable. Vegetables are the manufacturers or producers of protein; animals are the destroyers or consumers of it.[1] You have now found that the torula or yeast-cell is a plant, and not an animal. The next question is, What kind of a plant is it? Mostly all plants need the sun, but the yeast-plant grows as well in the dark as in the light. Plants that need the light are always green; they take in carbonic acid, and give off oxygen, but the torula has no green color, and it takes in oxygen and gives off carbonic acid. Those plants which give off carbonic acid, grow in the dark, and are not green, are called fungi. The mushrooms and toadstools are fungi. Now let us see how many things you have learned about yeast: First, that it is alive; second, that it is a plant; third, that it is a fungus.

When first you try to study this lobster, you will perhaps think, as I thought, "How can I straighten out such a queer, crusty, clawy thing as that?" But, though the lobster looks as hard as the Greek alphabet, he is as easy as your own A, B, C, when once you find him out. You know the corolla or crown of the bean looked so hard, but it all came out nicely into five leaves, or petals, as soon as you knew how. Now let us see if we can find and name the different parts of the lobster. (You must have a real lobster before you to look at while I talk. The crawfish or crayfish that lives in brooks and rivers is fashioned after the lobster, only smaller; so one of these can be studied by those of you who live inland.) One thing is very certain—he has a great many different parts, very unlike each other. First, you see (Fig. 15), he is covered with a shell, which, like the mussel's and clam's, is his exo-skeleton. This shell is very hard, like stone, and it is colored purplish black with pale spots here and there. The lobsters which you see in shops are always scarlet. When these poor fellows are caught, they are plunged alive into boiling water, which turns the black coat red. This outside shell or exo-skeleton is made up of a great many different pieces, instead of two, as the mussel's; but those pieces are shaped and joined in such a way as to make three divisions of the body—a head, a thorax, or breastplate, and an abdomen. The head-piece of the shell is pointed in front, forming the beak or frontal spine (Fig. 15). Behind this head-piece is a groove or seam where the head joins the breast or thorax, making the two pieces of shell which cover the head and breast all one. So the first and second divisions of the body thus joined in one are called the cephalo-

[1] Such plants as the Venus fly-trap seem to be an exception to this demarcation between the two kingdoms. These plants really digest protein matter, being supplied with what may be termed prehensile organs for capturing their prey. Dr. Hooker suggests that these plants are not exceptional and singular; that they simply continue through life the process begun by the germ when it nourishes itself upon the ready-made food stored up in the seed.

thorax or head breastplate. The large piece of shell, with the seam that covers the back and sides of the cephalo-thorax, is called the carapace or shield (Fig. 15). It is the front sharp point of this shield (carapace) that is called the frontal spine or beak. Behind the head and breast (cephalo-thorax) lies the third division of the body—the

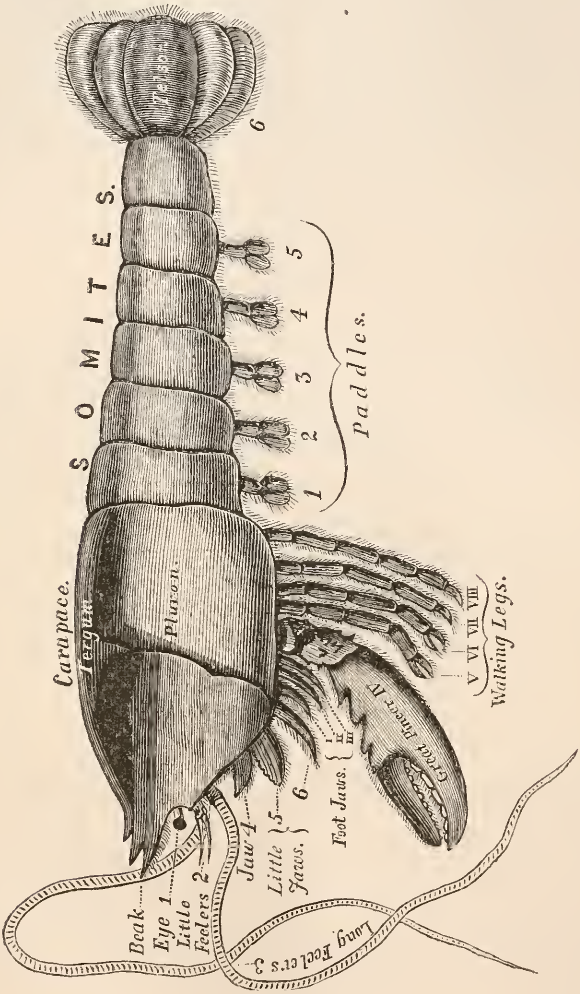


Fig. 15.

abdomen—which is made up of seven pieces or joints. The first six joints are called somites (Fig. 15) or bodies, and the last joint or tail-piece is called a telson, which means end. So the body of the lobster is made up of six somites and a telson. Each body-piece has a pair of soft-jointed paddles on its under side (Figs. 15, 16), and these are called swimmerets or little swimmers. The lower joints of these paddles have two broad, flat toes. The paddles on the last or sixth somite are different from the others; they are wider and turned backward (Fig. 15) so as to lie at each side of the tail-piece, telson; and these great-fingered paddles, taken with the telson, form what is called the tail-fin. The under or ventral part of each somite, which lies between the paddles, is called the sternum. The rounded upper or dorsal part of the body-piece is the tergum, which means the back. In front of the abdomen, with its somites, is the cephalo-thorax. This cephalo-thorax has a tergum, or back part, a sternum, or under part, a pleuron, or side part (Fig. 15), and so many things

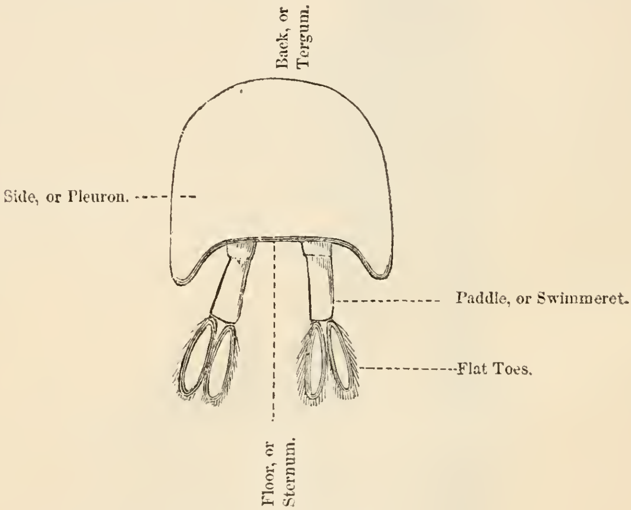


Fig. 16.—One of Lobster's Body-pieces, or Somites.

are hanging down from it one can hardly count, much less learn them. Counting from behind forward, you will find between the lobster's body, or abdomen, and the head, eight pair of jointed legs, one pair much longer and larger than the others, with huge pincers at the ends. All these eight pair are called the thoracic appendages, because they are fastened to the thorax, or breastplate. The lobster uses the four back-pairs for walking, and so they are called the ambulatory limbs. The last pair has seven joints, and every joint works in a different direction; so, when these hind-legs start off, it is hard to tell where they intend to go. The next pair of walking-legs are like the hindmost pair, except that the first joint sends out a piece above it, which is kept out of sight in a little room in the side of the lobster (Fig. 22). We shall say more about this room by-and-by. The two front pair of walking-legs send up pieces also into this chamber, but the end of the leg is different from the last two pairs, for they have pincers, or chelæ. Now we have come to the largest pair; the chelæ, or pincers at the ends, are so large and strong that they are called the "great chelæ." They are the lobster's weapons of defense. When he is taken prisoner, that is, seized by one of his claws, he quietly leaves the claw in the hands of his astonished captor, and beats his retreat as fast as possible. He has another odd way of laying down his arms when he is frightened by a great noise, such as thunder, or the firing of a cannon. It is no uncommon thing to find a number of these broken swords lying about among the rocks, showing where there has been a lobster fright or fight. As soon as one claw goes, another takes its place, but it is some time before the new one gets as long and strong as the old one. You will notice quite a difference between the two large claws, or forceps. In one, the teeth are large and blunt (Fig. 17), and in the other they are very sharp (Fig. 18).

FIG. 17.—LARGE-TOOTHED CLAW.

FIG. 18.—SMALL-TOOTHED CLAW.

The blunt-toothed pincers the lobster uses as an anchor to moor himself, while with the other he attacks and seizes his prey. So much for the great claws, or chelæ. The next three pair are called maxillipedes, or foot-jaws, because they act both as teeth and feet (Fig. 15). The hindmost foot-jaw has three divisions. One branch passes up into the side-chamber of the lobster; the middle branch is long and jointed: this, and its fellows on the other side, act as a pair of scissors, cutting the food. The third branch is jointed, and is a walking-leg. The middle foot-jaw (maxillipede) is much like the last, while the front one does not send a piece upward into the side-chamber (Fig. 22), and one of its branches is flattened out, so as to look like leaves. The four walking-legs, the great pincers (chelæ) and the three pair of foot-jaws (maxillipedes), making eight pair in all, belong to the lobster's breast (thorax). Now we come to the head, which is provided with six pair of "hangers-on," or appendages. The two back-pair belonging to the head are called maxillæ, because they lie at the side of the mouth, and are like jaws. The hindmost of the jaws—or maxillæ—on each side has a boat-shaped, or oval plate (Fig. 22), which lies at the front entrance of the side-chamber, about which we will hear more presently. The ends of the front pair of little jaws (maxillæ) are leafy, like those of the front pair of foot-jaws (maxillipedes). Now we come to the jaw itself, or mandible, which has strong teeth, bears a small appendage, the palp, and lies at the side of the mouth. From all this you see that the mouth of the lobster is well armed with teeth and scissors to tear and cut its food. Counting from the front, it has first the true jaws (mandibles); then the two pair of little jaws (maxillæ); and these are followed by the three pair of foot-jaws (maxillipedes) making, altogether, six pair, which are all turned up against the mouth. In front of the jaw are two very long jointed feelers called antennæ, but you seldom see them at their full length (Fig. 15); they are easily broken (Fig. 19). Next to the feelers (antennæ) are two

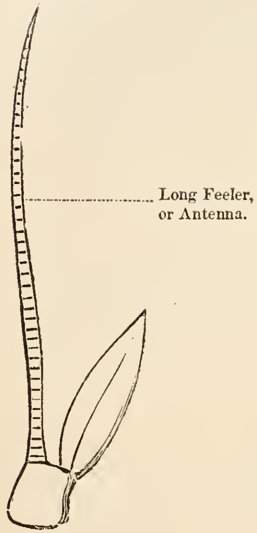


Fig. 19.

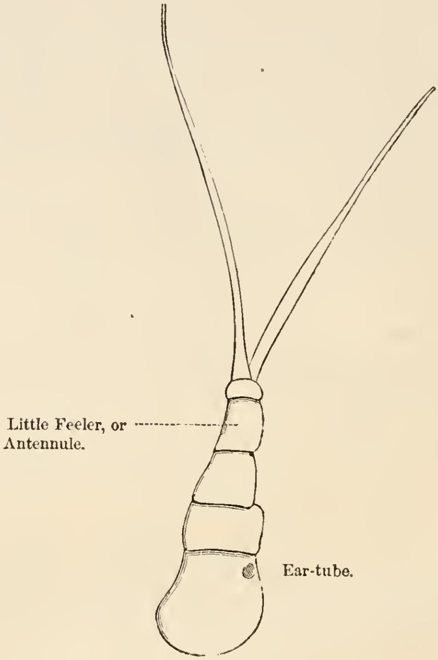


Fig. 20.

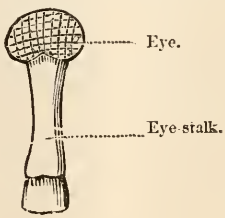


Fig. 21.

little feelers, or antennules (Figs. 15, 20); and last of all, in front, comes a pair of joints which support the eyes (Fig. 21), called the optic pair of appendages. Now let us begin with the eyes, and go back to the tail, to see how many pairs of feelers, jaws, hands, feet, and paddles the lobster owns (Fig. 15). He has six pairs attached to the head, eight pair to the breast (thorax), and six pairs to the body (abdomen); in all, twenty pairs, and very few of these appendages are alike.

NAMES OF LOBSTER'S APPENDAGES.

Head appendages.....	I pair....	Eye-stalks.	
	II "	Antennules, or small feelers.	
	III "	Antennæ, or great feelers.	
	IV "	Mandibles, or true jaws.	
	V "	Maxillæ, or little jaws......	First pair.
	VI "		Second "
Thoracic appendages..	VII "	Maxillipedes, or foot-jaws..	First "
	VIII "		Second "
	IX "		Third "
	X " ...	Chelæ, or pincers.	
	XI "	Ambulatory limbs, or walking-legs................	XI. and XII., with pincers.
	XII "		
	XIII "		XIII. and XIV., without pincers.
	XIV "		
Abdominal appendages.	XV "	Swimmerets, or little swimmers.	
	XVI "		
	XVII "		
	XVIII "		
	XIX "		
	XX "		

You now have a pretty good idea of the exo-skeleton, or hard outside part of the lobster, and we shall look next at the soft parts inside (Fig. 22). The mouth seems a very good place to begin at, and you will find it between the mandibles, or jaws. In front of it is a lip, shaped like an escutcheon, and is called the *labrum*, which means lip. At the back of the mouth is another lip, the *metastoma*, meaning beyond the mouth, and this is looked upon as the lower lip. The mouth, as in the mussel, opens into a gullet, or œsophagus. This meat-pipe opens into a four-cornered box (Fig. 22)—the stomach—which is very curiously made.

Near the centre of the box the walls come almost together, dividing it into two parts: the front part is the larger, and it is called the cardiac end, because in the human body the first part of the stomach points toward the heart, but you see, in the lobster, it points away from the heart. It contains three strong, colored teeth, fastened to a T-shaped frame (Fig. 23), and worked by muscles which are fastened to the inside of the breastplate (carapace). These teeth meet in the middle of the stomach, and form a powerful grinding-machine, which crushes the food like the stones in a mill (Fig. 24). Sometimes, when you find the empty shell of a lobster on the sea-shore, you can see a perfect mould of the old mill—"the mill-wheel gone to decay." How the lobster gets out of his shell, and how he turns the mill out of his stomach, we shall study after a while. The small back part of the stomach is called the pyloric end, and it is made inside like a sieve or strainer. The sides are stuffed out in the centre like cushions, and quite covered with hairs (Fig. 25). Let us see why. Pylorus means gate-keeper. It protects or guards the intestine from all intruders,

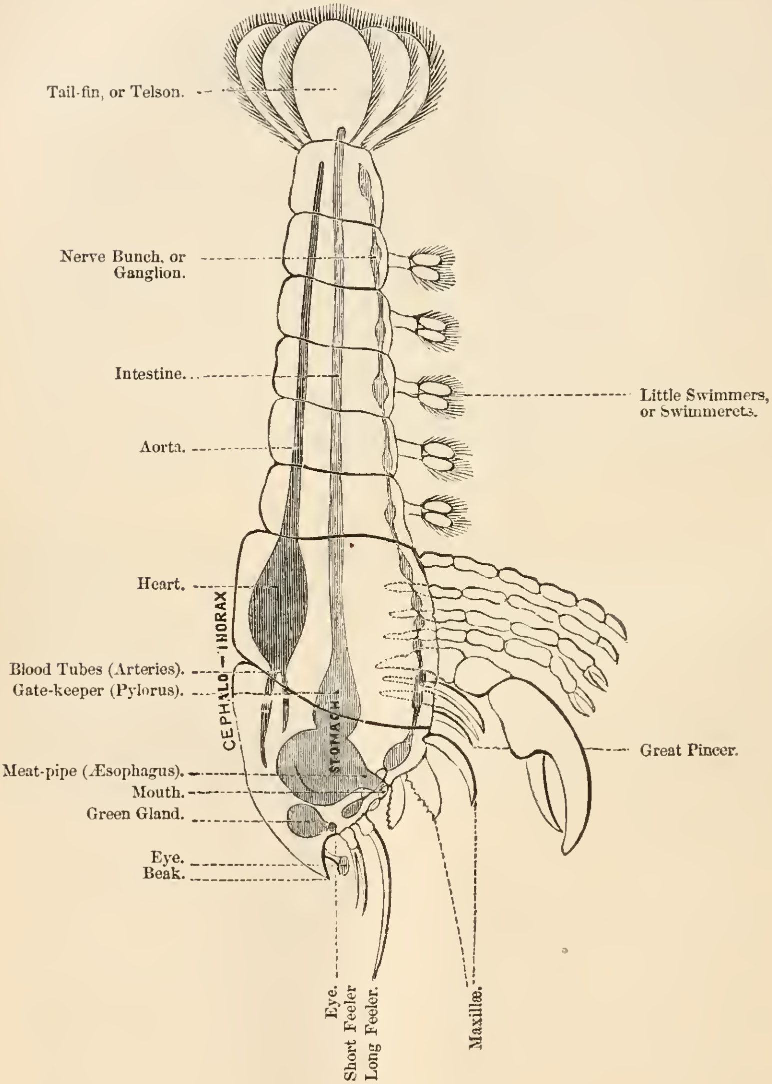


Fig. 22.

such as big pieces of meat and hard bodies. None but the finest particles can pass through the strainer, and hence this pylorus is a very good gate-keeper. The intestine does not go wandering about in the body like the mussel's, but passes straight back (Fig. 22), and ends at the anus, at the under part of the tail-piece (telson). On each side of the cephalo-thorax lies a long, soft, yellowish-green mass. This is the liver, and it opens into the small, pyloric end of the stomach by several ducts or pipes on each side. Away up in the front part of the cephalo-thorax, at the base of the feelers (antennæ) on either side

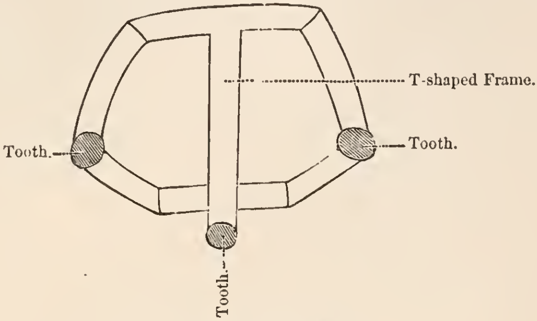


FIG. 23.—THE LOBSTER'S MILL.

you may see a soft green mass called the "green gland" (Fig. 22). This is supposed to be the kidney. Next we will take a look into the side-chambers (Fig. 22) of the cephalo-thorax, and see what the three pair of walking-legs, the great pincers (chelæ), and the two pairs of jaw-feet, are doing in there. In each chamber we find eighteen little,

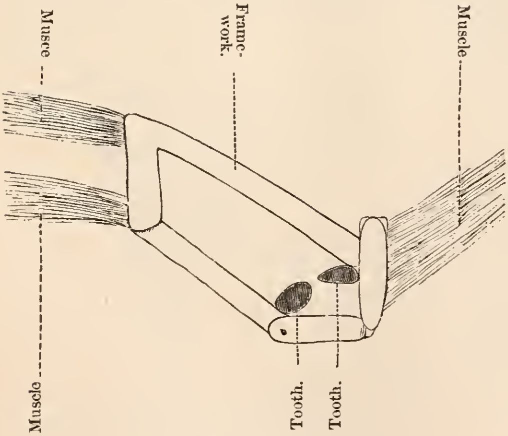


FIG. 24.—THE MILL AND ITS MUSCLES.

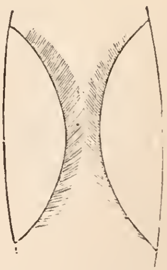


FIG. 25.—THE HAIRY CUSHIONS AT THE SMALL END OF THE STOMACH, THROUGH WHICH THE FOOD IS STRAINED.

tapering, feathery-like bodies. Each has a central stem, surrounded by fine, feathery filaments. They look very much like so many little bottle-brushes (Fig. 22). These are the gill-plumes, and this room is called the gill, or branchial chamber. The gills are placed in two sets, six in one and twelve in the other. The first row is fastened to the six feet or appendages of the breast (thorax) which we found pushing themselves up into the chamber (Fig. 22). The other twelve are fastened to the pleuron or side-pieces of the cephalo-thorax. These gills are not covered with stiff hairs (cilia) as the mussel's, so there must be some other plan of moving the water. There is a very curious piece of machinery at the front entrance. You remember the oval or boat-shaped plate in front of the chamber, formed by the hindmost little jaw (maxilla). This plate is called the scapho-gnathite, which means the little skiff-like jaw. It is made on the plan of the Archimedean screw, and it works as the screw of a propeller, and is set in motion by the jaws. The water enters the back part of the gill-chamber by a slit, and it is scooped out by the screw through the opening in front, bubbling and frothing as it goes. Thus the mechanism of the screw was all worked out in our little lobster long years before it was discovered by the great Archimedes. The tiny net-work of the blood-vessels is spread over the framework of the gill-plumes, just as you found it on the lattice-work of the mussel's gill-pockets. As the screw propels the water through the branchial or gill chamber the blood takes out the oxygen from the air in the water, and gives back carbonic acid. You remember how the strong hairs (cilia) of the pockets sweep the water along over the mussel's gills, and how the little blood-vessels take up their oxygen and give up their carbonic acid. The gills that are fastened to the legs move when the legs move, and the faster they go the more water they use. So much for the lobster's breathing or respiration. We will leave his circulation, his muscles and nerves, for another chapter.

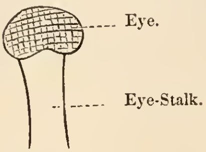


Fig. 26.

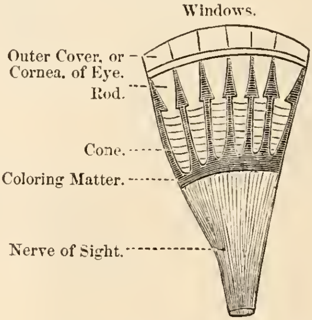


Fig. 27.—The Lobster's Eye, showing how the Nerve is joined to the Windows in front by the Rods and Cones.

The eyes, as you have seen, are away in front (Figs. 15, 22) at the ends of the first pair of appendages—the eye-stalks. The eye is kidney-shaped; instead of having one window or pupil as your eye has, through which the light enters, the whole front is divided into squares like old-fashioned window-panes (Fig. 26). Each square is really a separate eye, and this is what is called a compound eye. The lobster's eyesight must be very good, for, besides having all those eyes, the stalks are jointed so that he can turn them in different directions. The nerve which goes to the eye is called the optic nerve, and it is connected with each square by pretty rods and cones, which look like those in your own eye (Fig. 27). The rods and cones are covered with coloring-matter or pigment, which turns red when it is boiled. The optic nerve is a nerve of sensation, because it gives the lobster the sense of sight.

Now, where are the lobster's ears? Not in the foot, as the mussel's, but in their proper place—the head. If you look at the base of the little feelers, on each side you will find a little three-cornered slit, covered with hairs (Fig. 28). This slit leads into a small sac filled

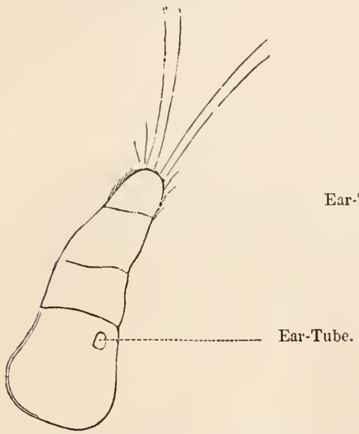


Fig. 28.—Little Feeler, or Antennule, showing Ear-Tube at its Base.

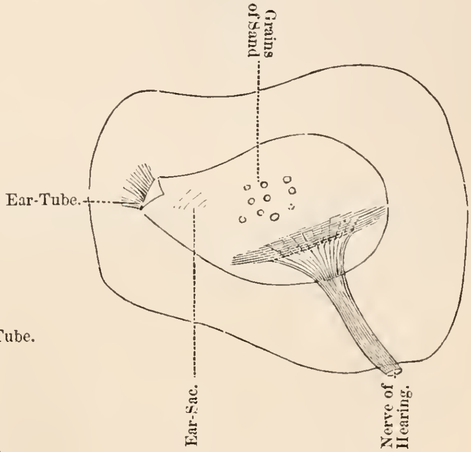


Fig. 29.—The Lobster's Ear.

with water. One side of this sac is pushed inward to form a sort of fold or pocket, in which a nerve which comes from the brain or head—ganglia—spreads itself out (Fig. 29). The side of the pocket toward the water is covered with fine hairs, and these hairs touch against little bits of sand which get into the water through the outside slit (Fig. 30). These particles of sand are like the tiny stones or otoliths you found in the mussel's ear-sac, and they, likewise, help to increase the sound. The lobster's ear is made on much the same plan as your own; the sac is really a fold of the lobster's skin, which is pushed in as you might push in the crown of your soft hat. Now, I dare say you are wishing to hear about the lobster's bairns or little ones. The lobster's eggs are covered by a soft, sticky glue, which fastens them to the long hairs which cover the paddles under the abdomen (Fig. 22). The good mother-lobster doubles up her body so that the eggs are all folded inward safe from harm. Hundreds of eggs are carried in this way, and when the lobster is boiled they turn red and form what is called the coral. The baby-lobsters differ greatly from their parents. Their eyes are very large, and set in the head instead of on eye-stalks. They have a great rounded head-shield (carapace) and a small body (Fig. 31). The limbs are not at all like the lobster's; altogether, he looks as if his eyes and head were running away with him. As soon as he is hatched he begins to swim about and feed himself, and never

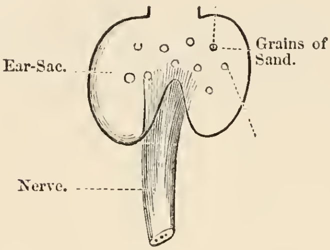


Fig. 30.

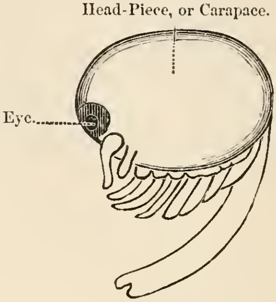


Fig. 31.—Young Lobster.

goes back to the old home. Of course, as he grows, his shell gets too small, but, instead of putting on an addition as the mussel does, he leaves the old house altogether and builds a new one. In three days after the lobster moves out of the old house he has been found all settled in a bran-new one one-third larger. Two round balls are often found in the lobster's stomach, and people call them "crab's-eyes." These balls are made of lime, which it is said the lobster has been storing up for his new shell. Thus the lobster moves "out of the old house into the new" every year till he gets his growth. Then he lives contentedly under the same roof till he dies, or till some one throws him into a lobster-pot.

THE ELECTRICAL GIRL.

TRANSLATED FROM THE FRENCH OF LOUIS FIGUIER, BY CLARA HAMMOND.

IN the beginning of 1846, a year memorable in the history of table-turning and spirit-rapping, Angélique Cottin was a girl of fourteen, living in the village of Bouvigny, near La Perrière, department of Orne, France. She was of low stature, but of robust frame, and apathetic to an extraordinary degree both in body and mind. On January 15th of the year named, while the girl was with three others engaged in weaving silk-thread gloves, the oaken table at which they worked began to move and change position. The work-women were alarmed; work was for a moment suspended, but was soon resumed. But, when Angélique again took her place, the table began anew to move with great violence; she felt herself attracted to it, but, so soon as she touched it, it retreated before her, or was even upset. The following morning similar phenomena were observed; and before long public opinion was very decided in affirming that Angélique Cottin was possessed of a devil, and that she should be brought before the parish priest. But the *curé* was a man of too much common-sense to heed their request for an exorcism, and resolved to see the facts for himself. The girl was brought to the *curé's* house, and there the phenomena were repeated, though not with the same intensity as before: the table retreated, but was not overturned, while the chair on which Angélique was seated moved in a contrary direction, rocking the while, and giving Angélique great difficulty in keeping her seat. These effects were so remarkable as to attract a great deal of attention; and so many came to see the demonstrations that the girl's relations, who were in straitened circumstances, thought to make a lucrative business of her singular faculty by exhibitions from time to time. Various professional men testified to her performances, of which the following letter from Dr. Beaumont-Chardon, of Mortagne, gives the usual account:

"This is what I saw," says this physician.

"1. Repulsion and attraction, bounding and displacement of a massive table; also of another table, mounted on casters, about three metres by two; another square table, in oak, about a metre and a half in size; an arm-chair, of mahogany, very massive. All these movements took place from the voluntary or involuntary contact of Angélique's clothes.

"2. When she was seated, overturning and repulsion of the young girl and the person who was occupying the same chair; a momentary adherence of the chair to the girl's dress was seen several times. Cessation of these effects when the chair and the young girl were placed upon glass or oil-cloth, or when the girl was placed upon the chair without having the feet of the latter touch the floor, effects generally less upon waxed floors or carpets.

"3. Great disturbance noticed in the girl, recalling that which is produced by an electric discharge, when a piece of wood, a stick, a shovel, or tongs, was brought in contact with the vertebral column. My finger held toward her forehead, or the top, and above all, the back of her head, either by actual contact, or at a distance of two centimetres, produced the same effect as it had done when brought in contact with the elbow of the left arm—disappearance of this effect when a piece of oil-cloth was interposed between the arm and the object.

"4. Painful and insupportable sensation of itching when one or two iron rods, strongly magnetized, were held several centimetres from the extended fingers of her left hand, or from her head; non-magnetized iron did not produce this effect. A magnetized needle, suspended horizontally from the ceiling by a long thread, deviated from the direction of the terrestrial magnetic axis, and oscillated at the approach of the girl's left arm.

"The young girl was generally heavily charged when I was near her, because I did not arouse in her any feeling of mistrust, but always endeavored to spare her suffering; I thought that, in order to appear to the best advantage, her mind must be free, and she herself gay and lively, although her will seemed to be entirely void of influence."

Angélique's relatives resolved, at length, to take the *electrical girl* to Paris in order to submit her to the examination of the academicians. During the public *séance* on the 17th of February at the Académie des Sciences, the secretary, Arago, published the experiments to which Dr. Sanchon had subjected the girl, and read a notice given him by this physician, which appeared in the official *Compte Rendu* of this session. It is as follows:

"I have twice," says Dr. Sanchon, "seen the electrical girl (Angélique Cottin). A chair which I was holding as firmly as possible with my foot and both hands, was suddenly torn from my grasp when she sat upon it. A little strip of paper which I balanced on my finger was blown away several times as though by a sudden rush of wind. A dining-table of considerable size, and quite heavy, was several times displaced and pushed by the mere contact of the girl's clothes. A small paper wheel, placed vertically or horizontally upon its axis, received a rapid motion from the emanations which proceeded from the child's wrist and elbow-joint. A very large and heavy sofa, on which I was seated, was violently pushed against the wall when the young girl placed herself beside me. A chair held to the ground by strong persons, on which I sat in a manner so as to occupy but half of it, was suddenly pushed from under me when the girl sat upon the remaining half. A remarkable fact is, that each time the chair was raised, it seemed to adhere to the girl's clothes; she followed it for an instant, and then disengaged herself. Two little balls of elder-wood, or small pieces of quill suspended by a silk thread, were disturbed, attracted, and finally separated one from the other.

"The young girl's emanations were not permanent during the day; they appeared in the evening, from seven to nine o'clock: this gives me the idea that her last meal, which she takes at six o'clock, has some influence in regard to them. They recurred on the anterior surface of the body, particularly at the wrist and elbow. They only recurred in the left side; the arm on this side was warmer than the other; a gentle warmth was radiated from it as from a member on which a vivid reaction takes place. This part of the body was trembling and continually affected by unusual contractions and quivering, which seemed to be communicated to any hand that touched her. During the time that I noticed this young person, her pulse varied from 105 to 120; it often appeared irregular. When the girl was removed from the common reservoir, either by placing her in a chair without letting her feet touch the ground, or by resting her feet against those of another person standing before her, the phenomenon did not take place; it also ceased when she put her hands beneath her on sitting down. A waxed floor, a piece of oil-cloth, or a plate of glass, put under her feet or upon her chair, equally destroys her electric faculty.

"During the paroxysm, the girl can hardly touch any thing with her left hand without causing it to be thrown some distance; when her clothes come in contact with pieces of furniture, she attracts, displaces, and finally overturns them. This will be better conceived when the fact is known that, at each electric discharge, she endeavors to escape in order to avoid the result; she says that she always feels a pricking sensation at her wrist and elbow. In searching for the pulse in the temporal artery, not being able to appreciate it in the left arm, my fingers inadvertently touched the nape of the neck; instantly the girl uttered a cry, and disengaged herself from me. In the region of the cerebellum (I have tested this many times), where the muscles of the upper portion of the neck are inserted into the cranium, there was such a sensitive spot that the girl could not bear to have it touched—a spot which retained all the sensations she felt in her left arm.

"The child's electric emanations seemed to occur at intervals, and successively, in different portions of the anterior part of her body. I remarked on this occasion that in the displacement of the table, which requires great force, the electricity was in the base of the brain.

"Whatever these emanations are, they are produced by a gaseous current producing a sensation of cold. I distinctly felt a momentary breath upon my hands, similar to that made by the lips.

"This irregularity in the emission of the fluid seems to result from numerous causes. First, the continual preoccupation of the girl, who always glances behind her when any one or any thing touches her; and, finally, the apprehension which she has of the phenomenon; for, as soon as it becomes manifest, she rapidly endeavors to escape, as though repulsed by some contrary force. It is only when she thinks of nothing, or when her thoughts are otherwise engaged, that the phenomenon is most sudden and intense.

"Each phenomenon is marked by extreme fright in the girl, flight, and a general air of alarm. When she touches the north pole of a magnet with the end of her finger, she receives a violent shock. The south pole produces no effect. The magnet was charged in such a manner that the north pole could not be distinguished from the south; but the young girl knew the difference.

"She is very strong and in excellent health. Her intellectual capacities are but little developed; she is a village girl in every sense of the word.

"PARIS, *February* 15, 1846."

After having read the preceding notice, Arago related all that he had himself observed concerning Angélique Cottin, whom her relations had taken to the Observatory. In the presence of MM. Mathieu, Laugier, and Gougin, he confirmed the following phenomena: When Angélique Cottin touched a sheet of paper lying on a table it was instantly attracted toward her hand. Angélique approached a table, which was repelled as soon as it came in contact with her apron. She seated herself upon a chair with her feet resting on the floor, and the chair was thrown violently against the wall, while the young girl was sent in another direction. This experiment succeeded whenever it was tried. Neither Arago, Gougin, nor Laugier, could hold the chair immovable, and M. Gougin, seating himself in one-half of it, while the girl occupied the other, was thrown upon the floor as soon as she took possession of it.

Arago then asked that a committee should be appointed to examine these phenomena. The Academy selected Arago, Becquerel, Isidore Geoffroy Saint-Hilaire, Babinet, Rayer, and Pariset.

This committee assembled, on the following day, in the Jardin des Plantes, but the experiments were unfavorable in regard to the reality of the electric properties of Angélique Cottin.

Here is the committee's report:

"In the session of the 16th of February the Academy received from M. Cholet and Dr. Sanchon two notices relative to the extraordinary faculty which, it is said, was developed about a month ago in a young girl from Orne, Angélique Cottin, aged fourteen years. The Academy, in conformity with its usual custom, appointed a committee to examine these alleged facts, and to give an account of the result. We will discharge this duty in very few words:

"It was affirmed that Mdlle. Cottin exercised a most intense action of repulsion upon bodies of all kinds whenever a portion of her garments touched them. Accounts were even given of heavy tables being overturned by the simple contact of a silk thread. No effect of this kind was manifested before the committee.

"In the narratives communicated to the Academy it was affirmed that a magnetized needle, under the influence of the girl's arm, performed rapid oscillations, and finally fixed itself quite far from the magnetic meridian. When tried before the committee, a needle, delicately suspended in the same way and under the same circumstances, experienced neither permanent nor momentary displacement.

"M. Sanchon thought that Mdlle. Cottin possessed the faculty of distinguishing the north pole of a magnet from the south pole, by merely touching them with her fingers. The committee was convinced, by varied and numerous experiments, that the young girl does not possess the capacity attributed to her of determining the poles.

"The committee need not enumerate these useless attempts. It will simply content itself with declaring that *the only one of the alleged facts which was realized before them was that concerning the sudden and violent movements of chairs in which the young girl seated herself.* Upon serious suspicions arising as to the manner in which these movements occurred, the committee has decided that they shall be submitted to an attentive examination. It frankly announces that the investigations tended to discover the fact that certain *habitual manœuvres hidden in the feet and hands* could have produced the observed fact. *M. Cholet now declared that the young girl had lost her powers of attraction and repulsion*, and that we should be notified as soon as they were restored. Many days have passed since, yet the committee has received no intelligence. We have learned, however, that Mdlle. Cottin is daily received in drawing-rooms *where she repeats her experiments.*

"After having fully weighed the circumstances, the committee is of the opinion that the communications transmitted to the Academy on the subject of Mdlle. Angélique Cottin should be considered *as never having been sent in.*

(Signed) "ARAGO, BECQUEREL, ISIDORE GEOFFROY SAINT-HILAIRE, BABINET, RAYER, PARISET."

DARWIN AND HAECKEL.[1]

By PROF. T. H. HUXLEY, F. R. S.

OCTOBER 1, 1859, the date of the publication of the "Origin of Species," will hereafter be reckoned as the commencement of a new era in the history of biology. It marks the hegira of Science from the idolatries of special creation to the purer faith of evolution. That

[1] "Anthropogenie. Entwickelungsgeschichte des Menschen" (History of the Evolution of Man). By Prof. Ernst Haeckel. Translation in press by D. Appleton & Co.

great conception, which had dawned upon the minds of the patriarchs of philosophy—which had been embalmed in the immortal poem of Lucretius—which had been submerged, but not drowned, in the muddy deluge of Hebrew mythology and schoolmen's philosophy (miscalled Christianity) in the middle ages—and had struggled to the surface, much besmirched, by Lamarck's help—at length stood upon a firm dry quay, built by Darwin's hand, and made water-tight by a goodly contribution of Wallace's cement.

For the first time in history, sound scientific reasonings—the force of which has increased with every year of the fifteen which have elapsed—introduced such conclusions as the following:

> "I believe that animals have descended from at most only four or five progenitors" ("Origin of Species," first edition, p. 484).
>
> "I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form" (Ibid., p. 484).
>
> "In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown upon the origin of man and his history" (Ibid., p. 488).
>
> ". . . I view all beings, not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Silurian system was deposited. . . ." (Ibid., pp. 488, 489).
>
> "As all the living forms of life are the lineal descendants of those which lived long before the Silurian epoch. . . ." (Ibid., p. 489).
>
> "There is a grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one" (Ibid., p. 490).

There is no uncertain utterance here. There has been no special creation. All beings which now live are descended from primordial forms which existed before the oldest fossiliferous rocks were deposited. Man is no exception, but he and his highest faculties are as much products of evolution as the humblest plant, or the lowest worm.

A more clear and bold statement of the scope and tendencies of the doctrine advocated by Mr. Darwin could not have been put into words; and those who recollect the somewhat fiery controversies which were carried on, during the years which immediately followed 1859, need not be reminded that the *cheval de bataille* of the opponents of Darwinism was, to hold up to scorn and ridicule the application of his views to man, so distinctly indicated by the author of the theory when it was promulgated.

It seems almost absurd to produce evidence of what is so notorious. Yet it happens to be worth while to quote an article which appeared in the *Quarterly Review* for July, 1860. It is a production which should be bound up in good stout calf, or better, asses' skin, if such material is to be had, by the curious book-collector, together with

Brougham's attack on the undulatory theory of light when it was first propounded by Young, and it is chiefly remarkable for the magisterial airs assumed by a critic so fearfully and wonderfully ignorant of the subject with which he deals that he believes the blood-corpuscles to be produced by evaporation of the blood![1] The following extracts will, however, leave no doubt that, even to so unprepared an apprehension, Mr. Darwin's language was plain enough:

"This is the theory which really pervades the whole volume. Man, beast, creeping thing, and plant of the earth, are all the lineal and direct descendants of some individual *ens*, whose various progeny have been simply modified by the action of natural and ascertainable conditions into the multiform aspect of life which we see around us" (p. 231).

"If, with Mr. Darwin, to escape the difficulty of supposing the first man at his creation to possess in that framework of his body 'false marks of nourishment from his mother's womb,' with Mr. Darwin you consider him to have been an improved ape" (p. 253).

"First, then, he (Mr. Darwin) not obscurely declares that he applies his scheme of the action of the principle of natural selection to MAN himself, as well as to the animals around him" (p. 257).

Exactly fourteen years after this distinct testimony to the plainness of Mr. Darwin's speech on these matters, last July, namely, the very same *Review* had an article entitled "Primitive Man." Possessed by a blind animosity against all things Darwinian, the writer of this paper outrages decency by insinuations against Mr. George Darwin, well calculated to damage a little-known man with the public, though they sound droll enough to those who are acquainted with my able and excellent friend's somewhat ascetic habits; and, by way of preparation for the attack upon the son, the anonymous reviewer charges the father with deliberate duplicity:

"It is one of the calamities of our time and country that unbelievers, instead of, as in France, honestly avowing their sentiments, disguise them by studious reticence—as Mr. Darwin disguised, at first, his views as to the bestiality of man" (*loc. cit.*, p. 63).

Messieurs the Reviewers, you diametrically contradict one another, and one of you must bear the responsibility of a direct and deliberate untruth: which is it? The one who, writing in July, 1860, said there was no obscurity about Mr. Darwin's views on this matter? Or the one who, writing in July, 1874, accuses him of having at first disguised his views? Settle it between yourselves. If it were necessary for me to give an opinion on so delicate a matter, assuredly I could have no ground for hesitation. For, on becoming acquainted with Mr. Darwin's views in 1858, I set myself to inquire, much more seriously than I had done before, whether the hiatus between man and apes, indicated

[1] The passage is worth embalming: "Or what advantage of life could alter the shape of the corpuscles into which the blood can be evaporated?" (*loc. cit.*, p. 247).

by the Cuvierian classification, and insisted upon by his followers, to the great satisfaction of the opponents of the doctrine of evolution, really had an existence in Nature. I came to the conclusion that it had none; I stated the grounds of these conclusions to those who attended my lectures in 1859–'60; a battle, which was somewhat notorious in its day, took place at the meeting of the British Association at Oxford in 1860, and turned upon Mr. Darwin's views of the evolution of man; while, in 1863, I summed up the then state of the question in a little book, entitled "Man's Place in Nature," which did its work in several languages beside my own, and is now out of print and gone to the limbo of forgotten things: which is its proper place, now that Mr. Darwin has had leisure to state his own views more fully, though not more distinctly, than in the "Origin of Species," in the "Descent of Man."

Mr. Darwin reticent about his views respecting the origin of man! Why, for years after the publication of the "Origin of Species," one could not go to a dinner-party without hearing them; and, whether you took up the last number of *Punch*, or the last sermon, the chances were ten to one that there was some allusion to the "missing link."

Under these circumstances, the high moral tone assumed by the *Quarterly* reviewer—him of 1874, I mean—is truly edifying. Joseph Surface could not have done better. Unless I err, he is good enough to include me among the members of that school whose speculations are to bring back among us the gross profligacy of imperial Rome. This may be doubtful. But what is not doubtful is the fact that misrepresentation and falsification are the favorite weapons of Jesuitical Rome; that anonymous slander is practice, and not mere speculation; and that it is a practice, the natural culmination of which is not the profligacy of a Nero, or of a Commodus, but the secret poisonings of the papal Borgias.

I remember that when, in 1862, I showed the proofs of "Man's Place in Nature" to a cautious and sagacious friend of mine—an expert in such matters—he had nothing to say against my arguments, but much to urge against the prudence of publishing them. Doubtless he foresaw that an unscrupulous critic, sheltered by his anonymity, might charge me with advocating the "bestiality of man," and with, thereby, endeavoring to loosen those moral bonds which hold society together. It seemed to me, however, that a man of science has no *raison d'être* at all, unless he is willing to face much greater risks than these for the sake of that which he believes to be true; and, further, that to a man of science such risks do not count for much—that they are by no means so serious as they are to a man of letters, for example. Happily, the reputation and real success of a votary of the physical sciences are now wholly independent of the periodicals which are pleased to call themselves "influential organs of public opinion." The only opinion he need care about, if he care for any—

and he is all the wiser and happier if he care for none—is that of about a dozen men: two or three in these islands, as many in America, and half a dozen on the Continent. If these think well of his work, his reputation is secure from all the attacks of all the able editors of all the "influential organs" put together. So that I do not suppose that Mr. Darwin troubles himself much about this charge of dishonest reticence, which would be so ludicrous if it were not so shameful to its author; and I have thought it worth while to expose its foolish falsity merely in the interests of the honor of English journalism, in the hope of putting a stop to such malpractices, by calling the attention of the public to the most conspicuous lapse from that honor which has happened within my recollection.

The book, the title of which heads this article, Haeckel's "Anthropogenie," is remarkable in many ways: not least as a milestone, indicating the progress of the application of the theory of Evolution to Man, since Darwin set us all to thinking afresh upon that subject.

The position I took up, in 1863, was a very guarded one, as the state of knowledge at that time demanded. All I had to say came to this: If there is reason to believe that the lower animals have come to be what they are by a process of gradual modification, then there is nothing in the structure of man to warrant us in denying that he may have come into existence by the gradual modification of a mammal of ape-like organization. And, of the many criticisms with which my little book has been favored here and abroad, I have met with none which, in the slightest degree, shakes that position.

Prof. Haeckel stoops at much higher game. His theme is "Anthropogeny"—the tracing of the actual pedigree of man—from its protoplasmic root, sodden in the mud of seas which existed before the oldest of the fossiliferous rocks were deposited, in those inconceivably ancient days, which, for this earth, at any rate, were the real *juventus mundi*, to its climax and perfection—say in an anonymous critic of strict orthodoxy and high moral tone.

It need hardly be said that, in dealing with such a problem as this, science rapidly passes beyond the bounds of positive verifiable fact, and enters those of more or less justifiable speculation. But there are very few scientific problems, even of those which have been, and are being, most successfully solved, which have been, or can be, approached in any other way.

Our views respecting the nature of the planets, of the sun and stars, are speculations which are not, and cannot be, directly verified; that great instrument of research, the atomic hypothesis, is a speculation which cannot be directly verified; the statement that an extinct animal, of which we know only the skeleton, and never can know any more, had a heart and lungs, and gave birth to young which were developed in such and such a fashion, may be one which admits of no reasonable doubt, but it is an unverifiable hypothesis. I may be as sure as I can be of any thing, that I had a thought yesterday morning, which I took care neither to utter, nor to write down, but my conviction is an utterly unverifiable hypothesis. So that unverified, and even unverifiable, hypotheses may be great aids to the progress of knowledge—may have a right to be believed with a high degree of assurance. And, therefore, even if it be admitted that the evolution hypothesis is, in great measure, beyond the reach of verification, it by no means follows that it is not true, still less that it is not of the utmost value and importance.

There is evidence which is perfectly satisfactory to competent judges, that we have already learned the actual historical process by which one existing species—the horse—came into existence during the Tertiary epoch. The evidence, based on the analogy of known developmental facts, that a three-toed *Hipparion* form, which lived in the Miocene epoch, gave rise, by suppression of the phalanges of its rudimental toes and some other slight modifications, to the apparently one-toed later Tertiary horse, is as satisfactory to my mind as the evidence, based on the analogy of known structural facts, which leads me to have no doubt that the said extinct *Hipparion* had a simple stomach and a certain kind of heart. If those so-called "Baconian principles," which everybody talks about and nobody dreams of putting into practice, forbid us to draw the one conclusion, they forbid us to draw the other.

The alternative hypotheses are two: either the Deity manifested his power on this earth, in the course of the Miocene epoch, by making the two primitive ancestors of all the horses out of inorganic matter, or something more unlike a horse than a *Hipparion* changed into one. The latter hypothesis is gratuitous and absurd. The former is not in itself absurd; but, unless the early chapters of Genesis mean something contrary to what they appear to mean (and one never knows what exegetic ingenuity may make of the "original Hebrew"), it is shockingly heretical, and I hasten to disown it, lest, by some such secret connection as bound Goodwin Sands with Tenterden steeple, it should land me in the cruelties of Caligula, and lead me to violate the precepts of the sagest of physicians, by indulging in Heliogabalian gluttony.

But, if the horse really has arisen in this way, what imaginable ground can there be for the enormous and, in that case, highly "un-Baconian" assumption that the deer, and the ox, and the pig, have arisen in any other way? And if there is—not perhaps the complete evidence that we happen to possess in the case of the horse—but still much better evidence than there is for the authenticity and genuineness of the books called by the name of Moses, that these animals have been produced by a similar method, why may not the hypothesis that they have so arisen take its rank among the probable conclusions of science? Even though it must, in candor, be admitted that, as we cannot live back into the Tertiary epoch and see what went on at that time, the hypothesis must always remain, in the strictest sense of the word, unverifiable.

The fact is, that if the objections which are raised to the general doctrine of evolution were not theological objections, their utter childishness would be manifest even to the most childlike of believers. But, if the evolution of all living forms, by gradual modification, is an historical fact, why should the attempt to reconstruct the details of that momentous history be regarded as less philosophical or less laudable than the attempt of a Niebuhr, or of a Mommsen, to build up, from ruined monuments, fragmentary inscriptions, and obscure and often contradictory texts, a connected and intelligible history of Rome? Active error may advance knowledge in its efforts to establish itself; and nothing is more remarkable than the number of great things, from the discovery of America to that of the antiquity of man, which have been brought about by the attempt to establish erroneous views. But sitting still, and being afraid to stir, for fear of making mistakes, is certain to end in ruin in science as in practical life.

Prof. Haeckel is not chargeable with the fault of sitting still, and it may be that he moves too quickly now and then. In his book there are some views which I, for one, do not agree with, but as to which it is just as likely I may be wrong as he. I wish he could be persuaded to take a more liberal view of the duration of life on the earth, though he is far less miserly on that point now than when the "Schöpfungsgeschichte," formerly noticed in the *Academy*, was published. I might desire that he would not mix up phylogenetic "Stammbäume" with objective taxonomy; and I might wish that he would be a little milder with his honest opponents, though I heartily applaud his practice of dealing with critics of the other sort as mere *feræ naturæ*.

But, when all is said and done in the way of objection, the "Anthropogenie" is a real live book, full of power and genius, and based upon a foundation of practical original work, to which few living men can offer a parallel. If anybody can read it without profiting by the abundant information and fertile suggestions of new lines of thought which it contains, all I can say is, that I envy him; and if anybody can read it without being struck by its clearness and methodical comprehensiveness, and without being convinced that the general line of argument is sound, whatever may be thought of the details, all I can further say is, I do not envy him. I trust that, like the "Schöpfungsgeschichte," the "Anthropogenie" may speedily find an English translator.—*Academy.*

"SPIRITUAL PIRATES."

BY S. H. HAYWOOD.

PIO NONO has recently given to the world his infallible opinion concerning Tyndall and other modern scientists. To his apprehension they are "spiritual pirates, seeking to destroy the souls of men," and he undoubtedly has great faith in that high legal authority which says, "Pirates all nations are to prosecute."

From the Catholic stand-point the figure has a special significance. These fearless scholars have embarked upon the high-seas of scientific thought and research. Truth is the prize for which they seek. For its sake they are willing to float a flag which is always regarded as hostile by those who choose to remain forever anchored in the harbors of tradition and superstition. Along their track many a bright beacon has already been set, which marks the spot where some precious fragment has been redeemed and where some error has found its grave. But never has a ray of their light reached us without a struggle with the powers of darkness. Over all these highways of national and international thought the pope would gladly hold supreme jurisdiction. Free thought and free inquiry in almost any direction are fatal to some vital principle of Roman Catholicism. To match metaphors with his Holiness, they are spiritual sappers and miners, whose strokes tell fearfully among the foundation-stones of the Vatican.

We must concede consistency, at least, to this position of the Catholic Church. The genius of its religion is authority, and are not its subjects likely to lie stiller in the dark than when it is light about them? It is interesting and significant to notice how little its attitude toward theological or scientific inquiry has changed within the last three hundred years. Spencer in his philosophy of evolution, Darwin in his theory of natural selection, Tyndall in recasting the definitions of matter, are denounced in the spirit, and almost in the diction, of the sixteenth century. And how did it fare with Louis Agassiz, teacher, when he first ventured to assert the diverse origin of the human race? Some of us can remember. The overt acts of persecution which followed and tortured Galileo, Vesalius, and Giordano Bruno, are at present prudentially suppressed; but the spirit of the inquisitor still pursues the scientist into his laboratory or observatory, and insists that he bring thence nothing that does not harmonize with the creeds of to-day.

If the pope, Cardinal Cullen, the Dean of Manchester, and others under Catholic or High-Church influence and control, had gathered unto themselves all existing misapprehension, misrepresentation, and invective, in this direction, it were scarcely worth while to comment on a position so natural and a course so consistent with long-established precedent. But, unfortunately, it is not so. The alarm is sounded along our own shores, and the Presbytery of Belfast finds an echo in many of our so-called evangelical churches, and even in some of those which are miscalled liberal. Our preachers seem to delight in aiming a sarcasm or shaft of ridicule at the "advanced thinkers," not forgetting to add all possible irony to tone and inflection. One sacrifices his usual taste and discrimination, and selects the epithet Pickaninny to contain his sneer. "Pickaninny Tyndall!" Does it mean any thing? If so, what? Another makes a somewhat singular classification of "infidels," putting Voltaire, Hume, Tom Paine, and Tyndall, into the same category, and consigning them all to a common and speedy oblivion. Another, more in sorrow than in anger, speaks of the "ponderous sentences of unbelief" in the Belfast Address, but quotes none of them. In a newspaper article, written at Christmas-tide to inculcate "charity, in its largest, broadest, most comprehensive sense," we read that "Science throttles Religion in high places—or tries to." By these scared theologians, scientific men are declared to be trying to annihilate the Bible, to dethrone the Lord Christ, and to exterminate the living God. Similar latent motives have always been imputed to the fraternity, and it seems quite unnecessary to disclaim them, since their own minds are entirely preassured of the safety of Deity.

Now, sneers, innuendoes, and glittering generalities, may be convenient weapons with which to assail unwelcome arguments and conclusions, but they are certainly very ineffective. Such opposition will never end the controversy. The very animus of Protestantism is investigation, and shall New England Christians ally themselves with the pope in endeavoring to suppress its processes and ignore its results? It is only the new truth, the latest discovery, the undeveloped scheme, that is thus assailed and abused. After it has stood before the world a few decades—some other startling thought having in the mean time stepped to the front—it quietly takes its place among established facts or principles, Biblical interpretations adjust themselves, and its exponents, living or dead, are duly applauded and honored. A long catalogue of names might be cited in illustration, including, besides many scientists, some of the noblest reformers, whose diaries record every shade of treatment from their contemporaries, from the most virulent abuse to cordial recognition. What name stands fairer to-day than that of William Lloyd Garrison? And what living man has been more defamed and reviled than was he while he stood in advance of public sentiment on the question of slavery? In the eyes of the American churches it was *their* "peculiar institution" which he was covertly attacking, making only a blind of the great Southern evil which his soul abhorred. All the familiar idioms of the sects were liberally used in his behalf, and he was "throttled" in Boston with something more tangible than rhetoric.

So the fanatics and infidels of one generation become the heroes and philanthropists of the next.

The Concord clique of philosophers has been in past years most bitterly denounced in orthodox circles, and the patriotic old town itself has been called "the hot-bed of moral poison," and various other names equally expressive of the temper of their originators. But now, the leader and exemplar of that radical coterie, the revered and beloved Emerson, lectures acceptably before the theological students of Andover Seminary, while its chapel pulpit has recently been occupied by a prominent Unitarian clergyman, who, thirty years since, would have been shunned by the Faculty as a teacher of dangerous and pernicious doctrine.

Agassiz was no less a truth-seeker, his spirit was no less reverent, his purpose no less pure, when he broached his unscriptural theory, than when he bowed his head in silent worship at the opening of the Penikese School. Now, when the year returns, and he returns no more, we could almost canonize his memory. But why was he anathematized a quarter of a century ago? Simply because his position at that time represented the flood-mark of scientific investigation. It has changed place since then, and Tyndall now stands at its level, and must bear the surging of every tide.

Nothing is more acceptable to the honest thinker than intelligent criticism. Matthew Arnold said ten years ago that it was the great want of Europe. Worthy antagonism is always a valuable auxiliary in the cause of truth. Under its eye, eloquence is not allowed to pass for evidence, nor assertion for argument. It stimulates and reënforces the scholar, and extinguishes the pedant. It tends to prevent men from becoming so ardently in love with their own theories as to be blind to their defects. If it is able, as at the best it is, to set in motion a counter-current of thought, clear and forcible, it has attained its highest uses and becomes a real power. But the mind of the critic should be to the thought before it as the plane-mirror, reflecting it in true colors and exact proportions; otherwise, instead of just criticism, there follows either too liberal indorsement or undue stricture, according to the bias of the writer.

Thus adequately to examine the scientific positions of the day, with a view of supplementing or subverting them, requires an amount of special preparation which few who have worked in other fields of thought have been able to make; for a certain familiarity with scientific nomenclature and experiment, which is often acquired collaterally by the good student, though of great interest and value to its possessor, is not a reasonable basis for revision of principles, methods, and deductions. The arts are all closely akin, and Sir Joshua Reynolds was a fine connoisseur in his own department, and perhaps, like Titania's transient love, he had "a reasonable good ear in music;" but he probably could not have written a competent *critique* on the construction of Bach's fugues, or supplied the missing harmony to the original score of the "Messiah." For a correct exegesis of the Apocalypse, or the Book of Job, we should not go to the scientist, but to the trained and acute Biblicist; and when our thoughts are turned toward the sources and interpretations of natural phenomena, to whom shall we look for direction and guidance, but to those who have made these phenomena their life-long study? "Every one for his own."

If the destruction of these more recent theories, or their immediate and unreserved acceptance, were our only alternative, there might be some excuse for attacking them, even with the very unsuitable and impotent weapons with which most of us are furnished. But why can we not suffer ourselves to "make haste slowly" in regard to these questions which are so difficult, and, in a certain sense, so remote? The most enlightened scientists hold their views not rigidly, but flexibly, expecting them to undergo various modifications, as truth is gradually unsealed and error eliminated. They invite both scrutiny and correction; and, when argument is met by argument, proof with counter-proof, when premises are shown to be false, methods insufficient, or inferences illogical, none are more ready and generous in acknowledgment of mistakes. The absence of assertion is particularly noticeable in their writings. Their opinions are frequently prefaced with such phrases as "So far as I can discover," "Is it not probable," "Are we not justified in believing;" thus appealing to the intelligence and discernment of the reader, instead of seeming to compel his acquiescence. Darwin's first words in the second volume of the "Descent of Man" are, "I have fallen into a serious and unfortunate error;" and he frankly states that his explanation of certain coincidences is wholly erroneous. Does this candid admission detract from his general trustworthiness? Certainly not, to the equally candid reader. In summing up the main conclusions at the close of this elaborate work, he alludes to the still higher destiny which man may hope for in the distant future; but he instantly checks the incipient speculation with the characteristic utterance of the true devotee of science: "But we are not here concerned with hopes or fears, only with the truth as far as our reason allows us to discover it. I have given the evidence to the best of my ability."

These untiring students ask only unrestricted right of search and freedom of discussion. Shall this modest request be practically denied them? Shall the weak timidity and the unreasoning hostility of the sixteenth century forever repeat themselves in the presence of a fresh idea? Verily, a stranger in the world of thought fares hard at our hands. We are forgetful to entertain it until its wings appear, and that is not Scriptural hospitality.

Tyndall beautifully says: "Science desires not isolation, but freely combines with every effort toward the bettering of man's estate. The lifting of the life is the essential point." Are the sarcasms of the preacher an effort in the same direction? Will his animadversions tend to make his hearers more charitable in their judgments of others? Will his sneers at an opinion which differs from his own be likely to raise the standard of tolerance and Christian courtesy? Is a leaning toward the belief that matter contains the promise and potency of all terrestrial life, incompatible with the ordering of the individual life in accordance with high-toned Christian principles? Or will the rejection of the Darwinian theory be sure to free us from prejudice and cheap ambitions?

An excellent tonic, for a mind that is weary of this constant challenging of leading scientists to unequal contest, is one of their own "Lay Sermons." In reading their literature, one soon passes into an atmosphere which admits no element of petty strife. Their spirits are finely touched to fine issues, and they seem to have attained that splendor of expression which, Emerson says, carries with it the proof of great thoughts. Byron's "Corsair" left a name "linked to one virtue and a thousand crimes;" and perhaps even the pope would allow to these spiritual types of the same order the one virtue of an almost faultless style. It is not splendor of imagery, or mere ornament of any kind, that gives it its peculiar charm. It is the beauty of exquisite fitness, of perfect adaptation. Language seems sensitive to the fervor of their thought, and yields to them all its wonderful vividness. Let us not be withheld by fear, by the restraints of inherited conservatism not yet outgrown, or by misdirected pulpit influence, from studying the pages of any book, magazine, pamphlet, or newspaper, containing the selected thoughts of scientists, carefully prepared for the general reader. They furnish some of the best material for daily consideration and conversation. We find in them a centre and sequence of thought, and a natural cohesion of parts, which favorably distinguish them from many popular productions, both written and spoken. They not only show us facts, they teach us to generalize from such data, and to put a proper relative value upon different ideas. They give us a clearer vision and an ampler horizon. They quicken the perceptions, mature the judgment, and purify the taste. And if, in his enthusiasm, a writer sometimes ventures beyond the limits of verified evidence, and gives one touch of imaginative coloring to the sober shades of reason and argument, can we not bear with it, when we remember with what infinite patience the world has for ages listened to baseless and useless conjectures, and sentimental fancies concerning heaven, its conditions, employments, and delights?

We are called to no decision upon these great questions, but let us study them, and draw from them all possible mental stimulus and moral force, and then be sure to give our personal influence in support of our highest convictions. The verdict rests with Time, and we know that under its slow, sure touch, all error must fall away, leaving Truth triumphant in the strength of her own immortality.

SOCIAL EVOLUTION.

By Prof. J. E. CAIRNES.[1]

ANXIOUS as all who take an interest in social speculation cannot fail to be for the completion of Mr. Spencer's forthcoming work on the "Principles of Sociology," they will scarcely regret that he should have allowed himself to be drawn aside for a time from his principal occupation in order to compose the present volume. Several reasons concur to make it desirable that such an *avant-coureur* should be sent forth; but it is sufficient here to mention one. With every possible disposition to acknowledge the great services of M. Comte in his masterly *ébauche* and partial development of the science of society, it is impossible not to see that even the elementary principles of this branch of inquiry have yet to be formulated. To constitute these, or at least some portion of them, is doubtless the aim of Mr. Spencer's grand undertaking. It is to this that the labors of his life have been leading up; but, if his work is to prove in any sense definitive, it is plainly an indispensable condition that it should be preceded by a tolerably full and thorough discussion of the more elementary doctrines of the new science. Mr. Spencer has not, indeed, waited till now to give the world his ideas on many social topics of the highest importance; but it was well thus to bring together into a single volume his sociological views scattered over many essays, and, by giving them fresh exposition and illustration, to invite fresh criticism. Never before has the conception of a social science been put forth with equal distinctness and clearness; and never has its claim to take rank as a recognized branch of scientific investigation been placed upon surer grounds, or asserted with more just emphasis. The wealth of illustration lavished on the various topics discussed is almost marvelous; and, when one considers that Mr. Spencer has already on hand a great work on the same subject, augurs a rare profusion of resources. The purpose of the present essay, however, is not to render to Mr. Spencer a homage of which he has no need, but to invite attention to some positions of his philosophical system, so far as it has been given to the public, which have scarcely yet received that amount of consideration and criticism which their great importance demands. As will be seen, and indeed has already appeared, the following remarks have been conceived from the point of view of one who fully accepts the possibility of a social science, and who, to a large extent, concurs in Mr. Spencer's conception of the nature of that inquiry.

The part of Mr. Spencer's social philosophy to which he has hitherto given most prominence, and which he has elaborated with most care, is his doctrine of Social Evolution. The idea was put forward

[1] A review of "The Study of Sociology," by Herbert Spencer. D. Appleton & Co.

by him, many years ago, in a well-known essay entitled the "Social Organism;" it has since received further elucidation in a discussion with Prof. Huxley in this *Review;* and it has once more been expounded anew, and with fresh illustration, in the present volume. There is a certain sense in which, I presume, the doctrine of "Social Evolution" would be now pretty widely accepted, at least among those who have concerned themselves with the philosophy of history and kindred speculations. I mean the sense in which it expresses the fact that each stage in human progress is the outcome and result of the stage which has immediately preceded it, and that the whole series of stages, beginning with savage life and ending with the most advanced existing civilization, represents a connected chain, of which the links are bound together as sequences, in precisely the same way as in the instances of causation presented by other departments of Nature. Some such assumption as this must necessarily form the basis of all attempts at a rational interpretation of history. But, as enunciated and expounded by Mr. Spencer, social evolution carries with it a meaning much more precise and significant. As his readers are aware, Mr. Spencer insists very strongly on the analogy of evolution, as exhibited in the animal kingdom, whether in the individual animal or in the species, and evolution in human society—in other words, between the development, individual and specific, of the animal organism, and the development of what he calls "the social organism," meaning, thereby, organized social life. He finds in this analogy not merely a metaphor and an illustration, but a type, and even a clew. Thus he observes a law of development governing the growth of an individual organism from birth to maturity; and, again, a similar law governing the development of species from existence in an all but amorphous germ to the attainment of a very high and complex form of animal life; and he transfers these laws from physiology and zoology to the domain of social science; treating them not merely as the means of elucidating social phenomena, but as exhibiting the real character of the processes by which mankind have in fact attained their present civilization, and as foreshadowing, also, the lines along which society in its future development is destined to move. It is, for instance, a characteristic of the evolution of individual organisms under the laws of animal growth, as well as of that of the several species of animals under the influence of the struggle for existence and the law of the "survival of the fittest," that development takes place "spontaneously"—that is to say, is the *incidental result of actions not consciously undertaken with that object in view.* This is evidently so in the growth of an individual animal, and it is no less certainly so in the development of species. In neither case is the progress attained the result of efforts consciously put forth for its accomplishment. And the whole drift of Mr. Spencer's teaching on this subject is to show that the process is similar in the case of human society; that its growth and development are in no degree, or at all events in quite an insignificant degree, the consequence of efforts put forth by those who compose it to improve their social condition, but mainly, if not exclusively, the result of actions undertaken with quite other ends in view. A favorite illustration, accordingly, with Mr. Spencer of the process by which society undergoes development is the growth of language:

"Not only has it been natural from the beginning, but it has been spontaneous. No language is a cunningly-devised scheme of a ruler or body of legislators. There is no council of savages to invent the parts of speech, and decide on what principles they should be used. Nay, more. Going on without any authority or appointed regulation, this natural process went on without any man observing that it was going on. Solely under pressure of the need for communicating their ideas and feelings, solely in pursuit of their personal interests, men little by little developed speech in absolute unconsciousness that they were doing any thing more than pursuing their personal interests." (Essays, vol. iii., p. 129.)

And this is given as a typical specimen of the "workings-out of sociological processes"—of the marvelous results "indirectly and unintentionally achieved by the coöperation of men who are severally pursuing their private ends." The numerous and complex arrangements which, under the stimulus of individual self-interest, have arisen in this and other civilized countries for the distribution of wealth, and the growth from small beginnings of our vast system of credit and banking, serve as an illustration of the same principle. "When it is questioned," he remarks, "whether the spontaneous coöperation of men in pursuit of personal benefits will adequately work out the general good, we may get guidance for judgment by comparing the results;" and he proceeds to give examples which could only lead to an affirmative conclusion.

The nature of social development is thus, according to Mr. Spencer, essentially identical with that of development in the animal kingdom; and it is a necessary corollary from this that the course of both should lie along parallel lines. Thus, when we find the individual animal growing from birth to maturity, developing its structure and functions according to a regular scheme; and, similarly, the several species of animals constantly tending, under the influence of the struggle for existence, to adapt themselves more and more perfectly to the conditions of their environment, and so to rise into a higher and higher order of being; when we find all this, and perceive that the processes by which society is developed are exactly analogous, the conclusion seems inevitable that so it must be also with social evolution—that here, too, progress and improvement arise by way of spontaneous growth in the natural order of things, and that consequently efforts to advance the common interest are superfluous—much more likely, in effect, to impede and disturb than to assist the harmonious order of human development.

Such, so far as I have been able to extract his meaning from his various essays on this subject, is Mr. Spencer's theory of social evolution. The practical effect of such a doctrine on all engaged in helping forward, according to the measure of their strength, the cause of human well-being, it is not difficult to perceive; nor does Mr. Spencer altogether blink this aspect of the case. In the last two pages of his recent work he has the following remarks:

"If, as seems likely, some should propose to draw the seemingly awkward corollary, that it matters not what we believe, or what we teach, since the process of social evolution will take its own course in spite of us; I reply that, while this corollary is in one sense true, it is in another sense untrue. Doubtless, from all that has been said, it follows that, supposing surrounding conditions continue the same, the evolution of a society cannot be in any essential way diverted from its general course; though it also follows (and here the corollary is at fault) that the thoughts and actions of individuals, being natural factors that arise in the course of the evolution itself, and aid in further advancing it, cannot be dispensed with, but must be severally valued as increments of the aggregate force producing change."

Whether this explanation will be satisfactory to those who draw the "seemingly awkward corollary," may, perhaps, be doubted. Mr. Spencer apparently does not rely much on the practical efficacy of his answer, for he at once proceeds to supplement it as follows:

"Though the process of social evolution is, in its general character, so far predetermined that its successive stages cannot be antedated, and that hence no teaching or policy can advance it beyond a certain normal rate, which is limited by the rate of organic modification in human beings, yet it is quite possible to perturb, to retard, or to disorder the process. The analogy of individual development again serves us. The unfolding of an organism after its special type has its approximately-uniform course, taking its tolerably-definite time, and no treatment that may be devised will fundamentally change or greatly accelerate these; the best that can be done is to maintain the required favorable conditions. But it is quite easy to adopt a treatment which shall dwarf, or deform, or otherwise injure; the processes of growth and development may be, and very often are, hindered and deranged, though they cannot be artificially bettered. Similarly with the social organism."

If I am not mistaken, however, the case of the social organism is not similar. The favorable conditions which it is important to maintain with reference to the individual organism are conditions external to the organism; whereas that condition of social development, the efficacy of which forms the question in dispute, consists in efforts after social improvement made by the units composing the organism. The analogy, therefore, of individual development completely fails us here, unless, indeed, Mr. Spencer supposes the objectors he is addressing to be standing outside the social organism, and proposing to experiment upon it as upon a foreign body. But, not to dwell on this point, the conclusion arrived at is that, "by maintaining favorable conditions, there cannot be more good done than that of letting social progress go on unhindered;" whereas "an immensity of mischief may be done in the way of disturbing and distorting and repressing, by policies carried out in pursuit of erroneous conceptions." Indifferent comfort, this, for the friends of humanity; but it is all Mr. Spencer has to offer. He adds "a few words," however, "to those who think these general conclusions discouraging. Probably the more enthusiastic, hopeful of great ameliorations in the state of mankind, to be brought about rapidly by propagating this belief or initiating that reform, will feel that a doctrine negativing their sanguine expectations takes away much of the stimulus to exertion. If large advances in human welfare can come only in the slow process of things, *which will inevitably bring them*, why should we trouble ourselves?" A very natural question. And what is Mr. Spencer's answer? Simply that on visionary hopes rational criticisms cannot but have a depressing influence. But "it is better," he adds, "to recognize the truth."

Doubtless "it is better to recognize the truth;" but before accepting as true a doctrine admittedly so depressing, carrying with it such "seemingly awkward corollaries," it will, at least, be well to subject it to a somewhat careful examination. And, in the first place, there is this remark to be made, that no verification whatever has yet been offered, or, so far as I know, attempted, of the theory of social evolution set forth with so much appearance of scientific authority. It represents a speculation transferred from the domain of physiology and zoology into that of social inquiry, and the speculation, so transferred, is applied, without question or scruple, to the interpretation of human affairs; no attempt having been made to ascertain how far the course of these affairs hitherto has corresponded with the doctrine thus formulated. The range of human history now covers upward of 3,000 years, and presents, in a very incomplete and imperfect manner, no doubt, the phenomena of moral, intellectual, religious, and other evolution in numerous societies of men. Surely, before propounding his speculation as a law of human society, from which he is at once justified in deducing consequences of the largest kind bearing upon human conduct, Mr. Spencer was bound to consider what amount of countenance or support it received from the evidence derivable from such fields of research; but from the application of this test he has wholly abstained. Will it be said that our knowledge of past history is so exceedingly slight and untrustworthy as to be unfit to furnish a datum for social speculation, and that verification had thus to be dispensed with as impracticable? Such a defense, it seems to me, is scarcely available in the present instance; for, while it is true that about particular events in history there is, in general, much room for doubt and for difference of opinion, this is not the case, or is in a very slight degree the case, with regard to certain broad generalizations which come out with considerable distinctness from the study of the past, and which are, in effect, the very generalizations needed in order to test Mr. Spencer's doctrine. Thus there cannot be much doubt that certain nations have, during certain centuries of their history, made rather rapid progress in civilization, but have afterward suffered an arrest, which has, in some instances, been followed by temporary or permanent decline; while, on the other hand, others, and these by far the more numerous, have continued for thousands of years in a condition almost, if not altogether, stationary. In his work on "Ancient Law," Sir H. Maine does not hesitate to say that—

"The stationary condition of the human race is the rule; the progressive, the exception." "In spite of overwhelming evidence," he remarks, "it is most difficult for a citizen of Western Europe to bring thoroughly home to himself the truth that the civilization which surrounds him is a rare exception in the history of the world. . . . It is indisputable that much the greatest part of mankind has never shown a particle of desire that its civil institutions should be improved, since the moment when external completeness was first given to them by their embodiment in some permanent record."

Again, it is a point upon which, I suppose, it may be said, historians are agreed, that, even in Europe for many centuries—starting, let us say, from the age of the Antonines, and ending with the eleventh or twelfth century—the movement in human affairs was on the whole steadily backward; the state of things existing at the latter date being, according to all the main tests of human well-being, far in arrear of the condition attained in the former epoch. It may be that these generalizations are superficial, that the learning of the world is here at fault, and that history better understood would support Mr. Spencer's view; or it may be that the current beliefs on the points in question are capable of being reconciled with the new doctrine. Be this as it may, it is not the less true that the verdict of history, as now understood by its most competent interpreters, is distinctly opposed to the theory of social evolution enunciated by Mr. Spencer. Now, this is a fact which has been completely ignored by that distinguished writer; he has simply passed it by as not concerning his argument; and in doing so has, as I contend, set at naught one of the best-understood canons of the inductive method—the canon that requires that hypotheses, before being accepted as laws of Nature, or made the bases of confident deduction, should be carefully verified by comparison with all available facts pertinent to the question in hand. M. Comte, who, as regards the particular point under consideration—the *necessarily progressive* character of human evolution—is at one with Mr. Spencer, understood otherwise the claims of the positive philosophy, and does, in fact, fairly attempt to grapple with the historical difficulties to which I have referred. It is true, indeed, his argument is by no means successful—at least so it seems to me—in establishing the required conclusion; but it is, at least, more satisfactory than total silence.

It follows, then, that Mr. Spencer's theory of social evolution can only be regarded, as matters now stand, as an unverified hypothesis, with this presumption against it, that it is at variance with such knowledge as we possess of the past history of mankind; and the doubt as to its soundness, which this circumstance cannot but suggest, will, I think, find confirmation, when we look closely into that analogy between the social and the animal organisms *on which the whole speculation is built up.* In the striking and ingenious essay in which Mr. Spencer first traced this analogy he frankly admits that it does not run on all-fours, and he enumerates no less than four points in which the analogy fails. There will be no need at present to refer to more than one of these: it is to the effect that, unlike the sentient life of animals, which is concentrated in the brain, the sentient life of societies is diffused equally over the entire surface—

"A fact," says Mr. Spencer, "which reminds us that, while in individual bodies the welfare of all other parts is rightly subservient to the nervous system, whose pleasurable or painful activities make up the good or evil of life, in bodies politic the same thing does not hold, or holds but to a very slight extent. It is well that the lives of all parts of an animal should be merged in the life of the whole; because the whole has a corporate consciousness capable of happiness or misery. But it is not so with a society; since its living units do not and cannot lose individual consciousness, and since the community as a whole has no corporate consciousness. And this is an everlasting reason why the welfare of citizens cannot rightly be sacrificed to some supposed benefit of the state, but why, on the other hand, the state is to be maintained solely for the benefit of citizens. The corporate life must here be subservient to the lives of the parts, instead of the lives of the parts being subservient to the corporate life."

I have called attention to this admission because it appears to me to involve very much larger consequences than Mr. Spencer seems disposed to allow—consequences, if I mistake not, fatal to this theory. For what does it amount to? To this, that, however closely the two organisms he has been comparing may correspond in certain details of structure and function, the main purposes of the two schemes—the ends for which alone all the contrivances exist, and with reference to which their goodness or badness must be judged—are essentially different; the aim of the one being to sustain the corporate existence, and to contribute to the corporate happiness; while that of the other can properly have regard only to the existence and happiness of the individual elements which compose it. This being so, what can be more preposterous than to erect the modes of organization furnished by the animal kingdom into patterns and exemplars by which to regulate the relations of social life? What does such doctrine come to but a proposal deliberately to sacrifice the substance to the shadow—the ends of social existence to the establishment of a fanciful analogy? The reader of Prof. Huxley's essay on "Administrative Nihilism" will probably remember the passage in which he turns the analogy in question against Mr. Spencer, and converts it into an argument in favor of extending the functions of the state, or rather shows how it might be thus converted:

"The fact is," says Prof. Huxley, "that the sovereign power of the body thinks for the physiological organism, acts for it, and rules the individual components with a rod of iron. . . . The questioning of his authority involves death, or that partial death which we call paralysis. Hence, if the analogy of the body politic with the body physiological counts for any thing, it seems to me to be in favor of a much larger amount of governmental interference than exists at present, or that I, for one, at all desire to see. But, tempting as the opportunity is, I am not disposed to build up any argument in favor of my own case upon this analogy, curious, interesting, and in many respects close as it is, for it takes no cognizance of certain profound and essential differences between the physiological and political bodies."

And Prof. Huxley proceeds to point out one of those profound and essential differences, which, if the reader will refer to his argument, will be seen to come, in effect, to very much what Mr. Spencer himself had admitted, in his original essay, in the passage which I have quoted. As the reader is probably aware, Mr. Spencer replied to Prof. Huxley's attack in an elaborate article, now printed in the third series of his collected essays; but, though he might have claimed to have anticipated the objection urged against him by pointing to the passage in which the failure of the analogy in the circumstance in question was admitted and even insisted on, he did not take this course. In truth, though he might thus have avoided the *reductio ad absurdum* with which he was pressed by Prof. Huxley, and might also have saved his own consistency, he could only have done so by the entire surrender of his main position; for he must have admitted that the all-sufficing analogy, "curious, interesting, and in many respects close" as no doubt it is, was yet, for the purpose of political argument, entirely destitute of cogency; and this was an admission which Mr. Spencer did not see his way to make.

It may still, however, be contended that, though of small account as a criterion in practical politics—in the sphere of what we may call the statics of sociology—this analogy between the individual and social organisms may nevertheless possess value in reference to the dynamical aspects of the social problem, as throwing light, that is to say, on the course of social evolution. And such, it appears to me, is the case so long as we confine ourselves to a very primitive stage in the social history of man. In that primitive stage (as Mr. Darwin has taught us), while man remains still a savage, and even perhaps for some time after he has emerged from the savage condition, the influences which mould his social development are substantially the same with those which govern the development of a species. It is not strange, therefore, that evolution in the human and in the animal kingdom should, during this period, follow a very similar course. But a time arrives in the progress of social development when societies of men become conscious of a corporate existence, and when the improvement of the conditions of this existence becomes for them an object of conscious and deliberate effort. At what particular stage in human history this new social force comes into play, we have no need here to inquire. What I am concerned to point out is that *it is a new social force*, wholly different in character from any which had hitherto helped to shape human destiny—wholly different, also, from those influences which have guided the unfolding either of the individual animal or of the species. We cannot, by taking thought, add a cubit to our stature. The species, in undergoing the process of improvement, is wholly unconscious of the influences that are determining its career. It is not so with human evolution. Civilized mankind are aware of the changes taking place in their social conditions, and do consciously and deliberately take measures for its improvement.—*Fortnightly Review.*

SKETCH OF DR. HENRY MAUDSLEY.

THOSE who are familiar with the growing literature of psychological medicine during the last quarter of a century will remember the appearance of various papers remarkable for literary brilliancy and expressive of the most advanced opinion which appeared, nearly twenty years ago, in the English periodicals devoted to this subject, and written by Dr. Henry Maudsley. He was then a very young man, and the promise of his early efforts has been thoroughly redeemed by his subsequent professional career. A voluminous and able writer, and an eminent practitioner, he is now among the foremost men in the branch of medicine to which he has devoted himself. The last quarter of a century has witnessed a great change in the mode of studying mental phenomena. The old metaphysical method, which confined itself mainly to introspection of consciousness, with no more regard to the organic conditions under which mind is manifested than as if such conditions had no existence, has been invaded, and perhaps it is not too much to say, as a method of study, has completely broken down. Not that the introversive study of the phenomena of consciousness has been abandoned, but its sufficiency has been completely discredited; and mental science takes a new departure with the recognition that its organic basis is a fundamental element in its problems. The physicians whose studies begin with the body and traverse the field both of its normal and abnormal states, were forced to consider the subject of mind from the corporeal side, and with reference to the exigencies of practice. Metaphysical speculation was fruitless for their purposes; the mind had to be considered as dependent upon material conditions. The new order of truths thus brought forward has had a profound influence upon recent mental philosophy, and, in this reconstruction and reëxposition of the science, the subject of the present sketch has had a prominent share. His contributions to the literature of the question have not only been valuable acquisitions to the profession, but they have also been well adapted for the diffusion of this kind of knowledge among general readers.

Henry Maudsley was born at Rome, near Settle, in Yorkshire, in 1835, and is, consequently, now but forty years of age. When his early academic studies were completed he chose the profession of a physician as a vocation, and entered upon the study of medicine at University College, London. His career as a medical student was eminently successful, and he obtained the highest honors in the different classes, and graduated M. D. at the University of London in 1856, at twenty-one years of age, having also obtained a scholarship, with the title of "University Medical Scholar." Selecting mental pathology as his medical specialty, he became resident physician and superintendent of the Manchester Royal Lunatic Hospital, a position which he held from 1859 to 1862. Resigning this appointment in 1862, he yielded to the temptations of the metropolis, and entered on a consulting practice in London. The speedy recognition of his professional claims led to his election as Fellow of the Royal College of Physicians in 1869, and the next year he had the honor of an appointment as Gulstonian Lecturer. Dr. Maudsley is Professor of Medical Jurisprudence in University College, London, and Consulting Physician to the West London Hospital. He has been President of the Medico-Psychological Association of Great Britain and Ireland, and is now, as he has been for some years, editor of that able periodical, the *Journal of Mental Science.* His labors have been appreciated on the Continent, and he has been elected Honorary Member of the Medico-Psychological Society of Paris, and of the Imperial Society of Physicians of Vienna, etc.

Dr. Maudsley's most important work is "The Physiology and Pathology of Mind," a standard treatise for the profession, and a repertory of interesting facts—an able exposition of mental phenomena in their organic relations. This work has passed through several editions, as has also the lesser volume which he subsequently issued, "The Gulstonian Lectures on Body and Mind." His contributions to the *Journal of Mental Science* have been numerous and important; and his last work, "Responsibility in Mental Disease," written for the "International Scientific Series," is an important monograph which has been widely read, and has contributed to extend the author's reputation.

Dr. Maudsley married the youngest daughter of the late Dr. John Conolly, whose name has been made eminent as the physician who first introduced into England, and carried out successfully, at Hanwell, that great reform, the non-restraint system in the management of lunatics.

CORRESPONDENCE.

THE FUTURE RELATIONS OF THE SEXES.

To the Editor of the Popular Science Monthly:

In the article on "Woman's Place in Nature," which appeared in the January number of The Popular Science Monthly, some applications of the general principles enunciated were omitted for the sake of brevity, and, deeming them important, I send them for publication, in continuation of that argument.

Although the characters peculiar to each sex have undoubtedly been acquired under the operation of the same laws, it would seem that men and women have become too much differentiated in their mode of living, for the physical or mental health of either. Among lower animals in a wild state, sex makes little difference in the habits of life; and, among barbarous tribes and races of men, there is little concerted action or differentiation of duties of men and women, except in the conduct of wars of rivalry or defense; and it has always been considered a sign of a higher civilization when woman is released from the heavier kinds of labor, and relegated to a special and different sphere of activity. But civilization, even, may be carried too far, in the extreme separation of men and women in their daily lives, no less than in the generally-acknowledged direction of the excessive refinements of metropolitan life; and there seems to be a tendency to a "reversion" in this respect, in an increasing disposition on the part of women to share, to a fuller extent than heretofore, the labors, the interests, the education, and the recreations, which do so much to give physical health and mental vigor to men. On the other hand, the sexual erethism, amounting to a pathological condition, so frequent among the men of to-day, may be regarded as an indication in the same direction. The greater strength of sexual passions in men is looked upon as a weakness and degradation by women—the "social evil" being largely attributed to it as a cause. While the brief review of the causes and conditions of the development of the race, given in a former article, shows, if both facts and deductions are accepted, that the higher traits of human character have arisen largely through this inequality, the fact of its having become excessive may be taken as an indication of the desirableness of a "reversion" for men as well as women; and, through a more intimate association in business relations, where the affinities of sex would be less powerfully asserted among sterner interests—where mere entertainment of each other would not be the occupation of the hour, as in social gatherings and dissipations—it is probable that a tendency would arise toward an equalizing of the sexes in this particular, which would contribute to the health of both; and that co-education, though advocated in the interests of women only, would result in advantage to both sexes.

An undue accumulation of electric force terminates in the thunder-bolt, which carries disaster in its pathway; while a more constant communication between cloud and earth tends to the maintenance of a safe equilibrium, by which means catastrophe is averted, and a better atmospheric condition secured.

While it would not be in accordance with the principles of evolution to say that woman does not now occupy her true and natural place in life, the fact of her increasing dissatisfaction with it is evidence that she is moving on to a better one—better, because higher in the scale of evolution. Says Lecky: "That the pursuits and education of women will be considerably altered, and that these alterations will bring with them some modifications of the type of character, may safely be predicted."

Since it is in the direction of greater moral as well as intellectual unfolding that the future progress of the race is undoubtedly to consist, woman will find ample fields for the expenditure of her special force and influence. I would not be understood to discourage women from entering any profession or department of labor to which they may feel themselves called. While thus developing their individual powers, it is probable that all the industries and activities of life would also be bettered by the introduction into their management of the spirit of "greater tenderness and less selfishness" which it would seem that heredity and selection have bestowed upon her. Our courts of law are often characterized by scenes of harshness, and brutality even; and surely the professions of theology and medicine furnish fitting fields for the exercise and culture of these beneficent qualities. Without doubt the possession of these traits, in a somewhat higher degree, by woman than by man, will counterbalance her disabilities in other directions, so that, in the struggle for success, she will suffer no serious disadvantage.

While intellectual arenas may always furnish a neutral ground where the two sexes shall meet on the common basis of actual achievement—where all work shall be submitted to the common test of merit —in matters of general interest to society, qualities essentially masculine on the one hand, or peculiarly feminine on the other, will turn the balance of power according as the interests or necessities of the hour are best subserved thereby. The existence of war would seem to furnish an extreme case in which masculine traits would be in the ascendant, and receive supreme consideration; but the hospital and the ambulance—the sanitary commission and the nurses' field-staff—present the converse of the picture, where feminine qualities assert their natural supremacy. On the other hand, "the instinct and genius for charity," ascribed to woman, find their executive force in the masculine arm, always at her command in carrying out her most generous conceptions.

Thus the contrasting phases of human nature meet and blend, like the forces at the opposite extremes of the spectrum, which, presenting the unlike characteristics of heat and actinism, unite in the visible middle ground, and speak in the beautiful language of color. Unrefracted, the full white ray of perfect light is manifested as a unit.

Solicitude is sometimes expressed lest an enlargement of the activities of woman, and the consequent mingling in the ruder scenes of life, should impair the delicacy and refinement which belong to womanhood; but this would seem to be a needless anxiety. Traits of character so inwoven in the very fibre of the nature as those which distinguish the sexes will not be easily eradicated, and the same laws which are now at work to check the too great differentiation of both in the direction in which they have hitherto tended, will prevent any excess of reaction. In this imperfect review of a subject commensurate with the history of the human race, at least, and generally believed to extend its rootlets to the lowest grades of organic life, we have seen that the key to the history of the evolution of the race lies in the distinction of sex.

This distinction, making its appearance at the very threshold of development of organized structures, *pari passu* becomes more marked and intricate with increased complexity of form and function, till perfect dualism is reached and exemplified in man, the crowning result of creation by evolution.

Its two phases, male and female, are not opposed in the sense of being antagonistic, but complementary rather, and so related that each finds development only in and through the other.

In the eloquent language of Roehsig—"The law of polarity, which applies seemingly to all inorganic Nature and controls the realm of life, gains its crowning efflorescence in the distinction of sex, and asserts its dominion over the operations of mind itself."

Frances Emily White, M. D.

Philadelphia, *January* 20, 1875.

EDITOR'S TABLE.

CAIRNES ON SOCIAL EVOLUTION.

IN an elaborate article contributed to the January *Fortnightly Review*, Prof. Cairnes has attacked the social philosophy of Herbert Spencer. The paper is too long to be wholly transferred to our pages, and so we reprint the first half; but that, it happens, is the most important part, and a little examination of its quality will show that not much has been lost by omitting the remainder. Coming from the source it does, we read the article with not a little surprise, for its writer either has no clear understanding of his subject, or he is trifling with it in a very inexcusable way. The subject is undoubtedly an important one, and is entitled to be considered with the utmost intelligence and candor. The *Saturday Review* tells us that "Englishmen hate men who offer them new ideas." This may be extravagant, but if it had said they hate men who offer them new ideas *upon social topics* it would probably have been nearer the truth. Social science implies that there are great natural agencies by which society in the past has been developed, and by which it is still largely regulated; but, of all people in the world, the English should be the least sympathetic with such a view, for nowhere else has Nature been more overlaid and buried out of sight by human arts, arrangements, and conventions, than in that country. But, whether under a patriotic bias or not, Prof. Cairnes is at no pains to conceal his dislike of Spencer's social doctrines. As a politician and a philanthropist enlisted in the service of humanity, he takes ground against their general influence. From this point of view he opposes Mr. Spencer to Mr. Mill as follows:

"On the one hand there is the philosophy of Mr. Spencer contemplating the career of humanity as fixed with regard to its main direction, as predetermined to move along certain defined or at least definable lines of progress, constantly shaping itself under the influence of causes which produce their effects spontaneously. . . . Can we have any doubt as to the tendency of such teaching? As to its paralyzing effect on laborers in the field of human improvement? . . . Contrast with this the teaching of that other philosophy with which Mr. Spencer's has been confronted in this discussion—the philosophy of Mr. Mill, every line of whose writings is instinct with the belief that there is nothing fixed in human fortunes—that it rests with the individual men and women of each generation as they pass, each within the range of his or her influence, to make or to mar them—whose creed it is that social progress is largely dependent on political institutions, which do not 'grow' while men sleep, but 'are the work of men—owe their origin and their whole existence to human will.'" Now, all that Prof. Cairnes can make by this contrast, he makes, not against any special system of sociological doctrine, but against the conception of natural law in social affairs; and yet he admits that the very creation of the social state is the work of spontaneous natural forces, such as have produced the diversities of life. He says: "In that primitive stage (as Mr. Darwin has taught us) while man remained still a savage, and even perhaps for some time after he is emerged from the savage condition, the influences which mould his social development are substantially the same with those that govern the development of a species." Again, he admits that "each stage in human progress is the outcome and result of the stage which has immediately preceded it, and that the whole series of stages, beginning with savage life and ending with the most advanced existing civilization, represents a connected chain, of which the links are bound together as sequences in precisely the same way as in the instances of causation presented by other departments of Nature. Some such assumption as this must necessarily form the basis of all attempts at a rational interpretation of history." But if Prof. Cairnes (without damping his reformatory ardor) can hold that society is bound in the chains of causation like "other departments of Nature," why should other laborers in the field of human improvement be paralyzed? If the holding of a belief in the utmost fatalism of law in social affairs is not sufficient to clip the wings or trip the heels of Prof. Cairnes's philanthropy, wherefore should Mr. Spencer be depressed, who avows no such extreme views? The effect, indeed, ought to be rather the contrary, for Prof. Cairnes maintains that his chain of causation, which is dragging the world's events along, is not raising or improving them, which would seem to be rather a gloomy reflection; while, on the other hand, Mr. Spencer holds that the great and irresistible tendency of things is toward a higher and better state, a view which is fitted to inspire something like the joy of a religious hope in a happier future. But, however that may be, Prof. Cairnes brings to the discussion of the subject his prejudices as a politician, or an Englishman, or some other perversity, and, as we are now to see, they blind him to the truth of the subject he has taken up.

Prof. Cairnes, as we have said, either does not understand Spencer, or he culpably misrepresents him. Everybody knows, or, at least, every one who writes upon the subject *ought* to know, that Mr. Spencer's labors for the last fifteen years have been only preparatory to the elucidation of the principles of sociology. He has but just entered upon that work which will occupy him, if he lives, for the next five or six years. The doctrine of social evolution he has not yet developed; and by that alone can he be fairly judged as a sociologist. Prof. Cairnes condemns him before he begins. His article is a review of the "Study of Sociology" which he assumes to embody "the elementary doctrines of the new science." But that work attempts no such thing; it, in fact, carefully avoids the consideration of the principles or science of the subject. It discusses outlying questions, which have, indeed, a bearing upon the general subject, but it is neither an exposition nor a defense of its elementary doctrines.

But, although Mr. Spencer's views upon sociology have hitherto only been put forth partially and incidentally, there is no excuse for such erroneous conceptions of them as Prof. Cairnes entertains. He goes back to an old essay on the "Social Organism," in which Mr. Spencer, nearly twenty years ago, pointed out some analogies between the structure and actions of the body politic and those of individual organisms, and says that Spencer's doctrine of social evolution is based upon this analogy. He asserts that Spencer's theory of social evolution "represents a speculation transferred from the domain of physiology and zoology into that of social inquiry, and the speculation so transferred is applied without question or scruple to the interpretation of human affairs;" and, again, he speaks of "that analogy between the social and animal organisms on which the whole speculation is built up." We cannot conceive a grosser misapprehension than this. Mr. Spencer maintains that the law of evolution is universal because the evidence of it is found in each of the great divisions of natural phenomena. In the social sphere the principle rests upon observed effects, and is an induction from the facts belonging to that sphere, just as strictly as the law of organic evolution is derived from facts in the biological field. This is abundantly shown in "First Principles," where the law, as applied to society, rests upon its own independent basis, and not upon the analogy of the social to the individual organism. So far, indeed, from proceeding by the method stated by Prof. Cairnes, Mr. Spencer actually proceeded by the reverse method: instead of beginning with biology and carrying out his conclusions to be applied to society, he began first, and early in life, the direct study of social phenomena, and pursued that line of inquiry many years before taking up biology. With Prof. Cairnes's criticism of the "analogy" we have nothing to do; nor is it of any importance that Huxley and Spencer had a controversy about it. The question is as old as Plato, and both Cairnes and Huxley admit that the analogy has some value—Mr. Spencer never claimed for it any thing more. We only say that the use the reviewer makes of it proves that he has taken but little pains to inform himself of Mr. Spencer's real doctrines.

Let us now consider Prof. Cairnes's main ground of attack upon Spencer's theory of social evolution. Calling attention to the fact that the social condition of the largest portion of the human race is stationary, and that there are numerous examples of social retrogression, he charges Mr. Spencer with ignoring these facts because they have no place in his theory of evolution. We have now, he says, three thousand years of history, and "surely, before propounding his speculation as a law of human society, from which he is at once justified in deducing consequences of the largest kind bearing upon human conduct, Mr. Spencer was bound to consider what amount of countenance or support it received from the evidence derivable from such fields of research; *but from the application of this test he has wholly abstained*" (the italics are ours). And, after referring to the backward movement of human affairs in Europe, for many centuries, he adds that "the verdict of history, as now understood by its most competent interpreters, is distinctly opposed to the theory of social evolution enunciated by Mr. Spencer. *Now, this is a fact that has been completely ignored by that distinguished writer:* he has simply passed it by as not concerning his argument; and, in doing so, has, as I contend, set at naught one of the best-understood canons of the inductive method." These passages, and the whole argument in which their thought is expanded, simply show (if we may be allowed to speak plainly) that Prof. Cairnes does not know what he is talking about. His statements are squarely against all the facts. So far is it from being true that Mr. Spencer ignores history in his social theories, that he has made the most elaborate and extensive preparations in this direction for future use in working out the principles of sociology. Nor were these preparations mere projects yet to be executed. The facts of the sociological history of England, on a most comprehensive plan, had been collated, and organized, and published a year and a half, when Prof. Cairnes comes forward to charge him with neglecting history. The professor, indeed, seems not to have the faintest idea of Mr. Spencer's real attitude toward his subject. Had he examined the work just referred to, which was his bounden duty as a reviewer, he would have discovered that, so far from ignoring history in social affairs, Mr. Spencer is doing more than any other man to bring it forward and give it its true place in the scientific study of society. He would have found that, of the three great social groups into which the human race is divided by Mr. Spencer, one is classified as low and stationary, and another as decaying or retrograding; and that the social career of the declining and dead civilizations, Jewish, Egyptian, Greek, Roman, Mexican, and Peruvian, are made the subjects of investigation, as well as the advancing communities of the present time. Prof. Cairnes declares that Mr. Spencer has "completely ignored" the phenomena of social retrogression, when within a year Mr. Spencer has issued the first volume ever printed on the sociological history of a group of decayed communities.

Nor is this all; there is even less excuse than now appears for the absurd misrepresentations in Prof. Cairnes's article. Mr. Spencer has commenced the "Principles of Sociology," and two numbers of that work had appeared before Prof. Cairnes published his criticism. Again we say, that he was bound to have consulted these, or have held his peace in regard to Mr. Spencer's doctrines. The following quotation from the part last issued, and which was printed two months before the *Fortnightly* article, will settle the question, and render any further notice of the professor's argument unnecessary:

"Evolution is commonly conceived to imply in every thing an *intrinsic* tendency to become something higher, but this is an erroneous conception of it. In all cases it is determined by the coöperation of inner and outer factors. . . . Usually neither advance nor recession results, and often, certain previously-acquired structures being rendered superfluous, there results a simpler form. Only now and then does the environing change initiate in the organism a new complication, and so produce a somewhat higher type. Hence the truth that while for immeasurable periods some types have neither advanced nor receded, and while in other types there has been further evolution, there are many types in which retrogression has happened. . . . Of all existing species of animals, if we include parasites, the greater number have retrograded from a structure to which their remote ancestors had once advanced. Often, indeed, progression in some types *involves* retrogression in others. For always the more evolved type, conquering by the aid of its acquired superiority, tends to drive competing types into inferior habitats, and less profitable modes of life; usually implying some disuse and decay of their higher powers.

"As with organic evolution, so with super-organic evolution. Though, taking the entire assemblage of societies, evolution may be held inevitable as an ultimate effect of the coöperating factors, intrinsic and extrinsic, acting on them all through indefinite periods of time, yet it cannot be held inevitable in each particular society, or even probable. A social organism, like an individual organism, undergoes modifications until it comes into equilibrium with environing conditions, and thereupon continues without further change of structure. When the conditions are changed, meteorologically or geologically, or by alterations in the Flora and Fauna, or by migration consequent on pressure of population, or by flight before usurping races, some change of social structure is entailed. But this change does not necessarily imply advance. Often it is toward neither a higher nor a lower structure. Where the habitat entails modes of life that are inferior, some degradation results. Only occasionally is the new combination of factors such as to cause a change constituting a step in social evolution, and initiating a social type which spreads and supplants inferior social types. For with these super-organic aggregates, as with the organic aggregates, progression in some produces retrogression in others; the more-evolved societies drive the less-evolved societies into unfavorable habitats, and so entail on them decrease of size, or decay of structure.

"Direct evidence forces this conclusion upon us. Lapse from higher civilization to lower civilization, made familiar during school-days, is further exemplified as our knowledge widens. Egyptians, Babylonians, Assyrians, Phœnicians, Persians, Jews, Greeks, Romans—it needs but to name these to be reminded that many large and highly-evolved societies have either disappeared, or have dwindled to barbarous hordes, or have been long passing through slow decay. Ruins show us that in Java there existed, in the past, a more developed society than exists now; and the like is shown by ruins in Cambodia. Peru and Mexico were once the seats of societies large and elaborately organized, that have been disorganized by conquest; and where the cities of Central America once contained great populations, carrying on various industries and arts, there are now but scattered tribes of savages. Unquestionably causes like those which produced these retrogressions, have been at work during the whole period of human existence. Always there have been cosmical and terrestrial changes going on, which, bettering some habitats, have made others worse; always there have been over-populations, spreadings of tribes, and escape of the defeated into localities unfit for such advanced social life as they had reached; always, where evolution has been uninterfered with externally, there have been those decays and dissolutions which complete the cycles of social changes. That supplanting of race by race, and thrusting into corners such inferior races as are not exterminated, which are now going on so actively, and which have been going on from the earliest recorded times, must have been ever going on. And the implication is that remnants of inferior races, taking refuge in inclement, barren, or otherwise unfit regions, have retrograded."

MENTAL PICTURING IN SCIENCE.

We pointed out some indications last month of the mitigated asperities in the Tyndall controversy, as evinced by the tone of the graver periodicals, and may now observe that a much more conciliatory and reasonable spirit begins to be manifested by the newspaper press. The topic is by no means worn out, and if our theological friends have the interests of education at heart, and are at all capable of gratitude, they will vote a medal of honor to Prof. Tyndall for his eminent services in arousing multitudes to think carefully upon important questions of which they have hitherto thought carelessly or not at all. There has not, in a long time, been such a general scientific and philosophic shaking-up as the Belfast Address has produced; and the result must be, that many will work their way to much clearer conceptions of the scope of science and its relations to religion.

A leading article appeared in the last issue of *Church and State*, in the most excellent temper. but still ingeniously protesting against some of Prof. Tyndall's views. In his late reply to his critics, the professor has said: "The kingdom of science, then, cometh not by observation and experiment alone, but is completed by fixing the roots of observation and experiment in a region inaccessible to both, and in dealing with which we are forced to fall back upon the picturing power of the mind." To this the writer takes exception, and questions whether it is right or advisable for the scientist "to fall back on the picturing power of the mind." He thinks it is allowable for the theologian to do this, but to scientists he says: "Why not go on observing, and leave others to conjecturing?" And, again, he remarks: "Of one thing we are sure, that, so far as the scientific investigators fall back upon the picturing power of the mind, they must relinquish the claims of *positive* science."

This strikes us as a quite erroneous view of the case. The scientific investigator can no more renounce the picturing faculty in his mind, than he can renounce the heart in his body; and he can no more confine himself to observing and leave conjecturing to others, than he can confine himself to digestion and leave respiration to others. To suppress the picturing power of the mind would put an embargo on all intellectual operations, and, in fact, put an end to thought itself. For what is thought but representation in consciousness, and what is it to represent but to reproduce mentally, to picture, to image, or exercise the image-forming faculty—the imagination? There are, of course, other mental operations, but they are performed upon the representations in consciousness—upon the objects of thought imagined, or imaged to the mind's eye. Not a step can be taken in science except by this mental procedure. The object of science is truth, and what is truth but the faithful representation in thought of the order and relations of natural things? Everybody imagines, but their mental images do not always correspond to the realities; their mental pictures *mis*represent. The man of science imagines—frames a view as the initial step of all his procedures; and then, by the mental processes of comparison, reasoning, inference, proof—guided by observation and experiment—he strives to give truth to his view; that is, to harmonize it with facts, and all its parts with each other. Our writer says that science starts with observation and experiment, but the real starting-point is farther back. A mental representation must be made before it can be verified. A certain state of things is conceived or put together in thought, and is called an hypothesis; and then observation and experiment are appealed to, to test the correctness of the representation—the truthfulness of the mental picture. Science is not merely seeing with the eye or fumbling with instruments—any blockhead can do these—but it is to reconstruct Nature in thought, representing all her diverse objects, subtile relations, and complexities of change, so truly, that by every test the representation shall answer to the verities. To do this, the imagination or image-forming faculty comes into incessant play. And more than this, the genius of the discoverer depends, first of all, upon the vividness of his imagination and the power of keeping his pictures steadily before the mind's eye until their errors are detected or their accuracy established. The work of science, in fact, consists, from first to last, in the *verification of mental pictures.* The scientific man must be fertile in imaginative resources, but stern in his rejection of views that cannot be adjusted to facts. The poet has no such discipline, for his object is not truth. The theologian has no such discipline, for he cannot submit his views to observation and experiment, so as to test their congruity with the objective world and with each other. The picturing faculty is employed by all minds, but only the trained scientist makes it subservient to the true understanding of the order of things around.

Sufficient has been said to show that imagination is indispensable to science; but it may be asked, "If observation and experiment are the means of science for controlling the imagination, and if they furnish the conditions of its valid exercise, why prolong the vision beyond the line of experimental evidence?" The reply is, that senses and instruments are imperfect, and their indications require to be supplemented by reason. They break down at a certain point, but that point is very far from being the limit of Nature. As experiments are perfected, the line of sensible demonstration is pushed backward constantly, disclosing a continuous order. It is a right of reason and a legitimate procedure of science, to pursue this order, if the explication of known phenomena require it. The results, of course, must conform to what is established—must harmonize with all that observation and experiment have gained; but thought may be compelled to go far deeper than experiment for the explanation of facts already known.

To make this statement more concrete, let us take the very case put by Prof. Tyndall—the ultimate constitution of matter. By various lines of proof, the physicist is brought to the conclusion that there are such things as amazingly-minute physical units which he calls molecules. In their smallness they are far beyond the border of all sensible observation; but he is driven to the conclusion that they exist as realities, and he has to represent them in thought. He mentally pictures a molecule as the smallest particle of matter that can exist separately and retain its physical properties. Prof. Thompson finds physical and mathematical evidence pointing down to the actual size of molecules. From this he infers that those of water have diameters that fall within the limits of $\frac{1}{2500000000}$ and $\frac{1}{5000000000}$ of an inch; and adds that, if we conceive a sphere of water as large as a pea to be magnified to the size of the earth, each molecule being magnified to the same extent, the magnified structure would be coarser-grained than a heap of small lead shot, but less coarse-grained than a heap of cricket-balls. The evidence in this case may be insufficient; it may become more complete; but the conception of physical units, in subsensible depths far beyond the reach of possible observation or experiment, is inevitable to the physicist and perfectly legitimate to science.

The chemist now steps in with a new view of the case. He accepts the molecule of the physicist, but to him it is no longer a unit. He decomposes it into new kinds of matter, with new properties. He resolves it into a still lower order of units, which he terms atoms. Chemistry presents us with a vast mass of observations and experiments, but they cannot be connected, resolved, interpreted, and stated, except in transsensible terms of the imagination—molecules and atoms. Physics and chemistry, in their latest and highest aspects, are compelled to fall back upon these conceptions of subsensible units as nothing less than the ultimate foundations of science.

THE INTERCOLLEGIATE SPOUTING-MATCH.

"The higher education" advances apace. We chronicled in due time the great impulse that it received at Saratoga last summer, when a mob that no man could number hustled its dusty way over to the lake to see which set of collegians could pull through the water the fastest. One of the boats came out ahead—as was rather unavoidable—whereupon everybody shook hands and uproariously agreed that this college business must be in a very prosperous way.

And now the "higher education" has taken another spirited stride forward. Half a dozen colleges in different parts of the country having made up a grand spouting-match, hired the Academy of Music in the metropolis for the exhibition, got together three newspaper editors for judges, brought on their most promising young declaimers, and let off the show before a large and admiring audience. Nothing was wanting to call out the best efforts of the candidates, who were fired by personal ambition, collegiate rivalry, auditorial applause, and impending newspaper glory, while even more peppery and pungent incentives were by no means overlooked. It is related that, on a certain occasion, the sportsmen somewhere out West resolved to have a grand fox-hunt in the true old English style. And so they came together with horses and hounds, not forgetting to bring the indispensable little beast they were going to hunt, which came secure in its cage. When all was ready, they let the fox go. The animal might probably have been trusted to run by natural instinct, but, to furnish him with an immediate motive for making his best speed, they gave him a cut with a horse-whip as he escaped. In the case of the young orators the starting-fillip was different. The high incentives might perhaps have sufficed to unseal the fountains of eloquence, but, to insure a gushing flow, an additional stimulus of $175 was held out as a premium to the winner. Whether the greenbacks were put in a purse and placed in conspicuous view of the contestants, does not appear. Be this as it may, they strove with each other, the editorial discrimination was invoked, some one got the money, and the others of course didn't; and it was agreed all around that the cause of the higher education had been moved along several notches.

Well, if the potsherds of the earth may be permitted to strive with each other, why not the colleges?—if the boys of the street may pitch pennies for the sake of winning them, why should not the students secure a little pelf by a trial of skill with their tongues? — all we ask is that the policy shall be formulated and recognized. We hope that in future the advocates of the perfection of our college system of culture will consent to regard it as a composite system working in various ways, and appealing to divers motives for the attainment of its ends. Hitherto we have been assured with great emphasis that this system—the perfected and purified result of centuries of experience—has risen above all low and sordid inducements, and rests its superior claims on the dignity of scholarship, the value of knowledge for its own sake, and the intrinsic excellence of culture. When it has been urged that college studies are susceptible of wise amendment, and should be arranged with some reference to the future needs of the student's life, the suggestion has been repelled with indignation, as born of a base, utilitarian, bread-and-butter motive that would degrade the lofty and disinterested ideal that should ever be held before the student—the cultivation and discipline of his intellectual powers, as an end in itself, to be debased by none of the vulgar incentives which animate the beastly crowd in the practical scrambles of life. To be sure, we have known that, notwithstanding all this sounding talk, the higher institutions have not hesitated to use the vulgar spurs of action by which human nature is everywhere moved. They are very far from having disdained the appeal to mercenary motives. The great universities of England are notoriously worked by cash bribes, in the shape of fellowships—honorary positions with incomes attached, which are securable by proficiency in certain prescribed studies. The universities have immense incomes and are enabled to cling to their mediæval courses of study in defiance of public opinion and the demand for reform, mainly through the pecuniary prizes which in this way they hold out to students. And this policy, in modified forms, is extending to other collegiate institutions as fast as they can get the money for the purpose. Rich people are inspired with the ambition of encouraging learning; that is, they get some crotchet or hobby of education, which they are willing to back with money, and then prizes are founded, and the students set into a fever of emulation to gain them. In this way sordid inducements become a part of the system, and, as most of the donors have been educated in the old way, their money goes to perpetuate it. But no sooner do the friends of science demand that modern studies shall have an equal chance with the ancient studies, and that the knowledge which is necessary for guidance in life shall be put upon an equality with dead languages, than the champions of the colleges are at once upon their dignity, and beg to know if the grand old liberal and ennobling culture consecrated by centuries is to go down before the narrow and selfish exactions of a materialistic and money-getting age. But these gentlemen are not, after all, unmindful of the educational potency of filthy lucre, nor that students may be plied with the motives of the gamester—the passion to win. The intercollegiate speaking-match had about it more of the ethics and incitements of the cockpit than is quite consistent with the lofty claims that are put forth in regard to the inspirations of the higher culture. We doubt if the multiplication of intercollegiate contests and ostentatious rivalries, whether for the winning of purses, or the beating of antagonists, or the exhibition of accomplishments, is either healthy in its influence upon the internal life of the institutions themselves, or favorable to that quiet, concentrated, uninterrupted mental exercise which is the indispensable condition of solid attainments and sterling scholarly character.

LITERARY NOTICES.

Report of the Chicago Relief and Aid Society of Disbursement of Contributions for the Sufferers by the Chicago Fire. Printed for the Chicago Relief and Aid Society, at the Riverside Press, 1874.

This volume is one of unique and remarkable interest, founded on one of the most terrible tragedies in all history. Within a period of twenty-four hours an immense portion of a great city was laid in ashes. The total area burned over was 2,124 acres, or nearly 3¼ square miles, containing about 73 miles of streets and 18,000 buildings, while, of a population of 334,000, the houses of 100,000 were destroyed. Of the experience of that terrible Sunday night, when the conflagration spread through the city before a driving gale of wind, the "Report" remarks as follows:

"As the fire raged, the number of homeless people became greater and greater, and, possessed by fright, many were inapt in expedients of self-preservation. Many sought temporary abodes for themselves and their effects in the hospitable homes of their neighbors. But the hope of security here was soon surrendered, and those who had been but mere spectators of their neighbors' calamities, were now panic-stricken householders, engaged in taking care of themselves, their families, and their property, until thousands together were fleeing west, north, and south, in consternation, and frequently in despair of saving life. And thus the streets were filled with an indescribable mass of fugitives forcing their way through the stifling clouds of dust, smoke, and cinders, and the confusion and utter chaos of the night—a night lurid with flames, the reflection of which, in itself, gave to the countenances of these fleeing thousands an awe-stricken and almost unearthly aspect. The hissing and crackling of the flames, and the deafening roar of the gale, the pelting cinders and brands, and the crumbling of material, gave tragic coloring to the scene, and leave the night memorable in the minds of those who witnessed it, as a picture of appalling horror, distinct in its outlines, weird in its dark shadings, but utterly incapable of verbal representation."

But, appalling as was this phase of the great disaster, the consequences it immediately entailed were hardly less dreadful:

"Comparatively few, of those who had fled before the flames, had tasted food since early Sunday evening, and hunger came to them to add its terrors to those of exposure and, in many instances, apprehension of death. And then came the greatest terror of all—the consciousness of the fact that families had been separated; husbands and wives, parents and children, were missing. The flight had been so rapid, and, in all directions, the thoroughfares had been so obstructed, and in some cases utterly impassable, by the crowding of vehicles and masses of people, and the city itself a wave of fire, it is no marvel that, under these circumstances, thousands, for the time, were lost sight of, and became lonely wanderers; and that hundreds perished in the flames. The seeds of permanent or temporary disease sown, the bodily suffering and mental anguish endured can never have statistical computation or adequate description."

Instant measures were required to meet the emergency. The news of the calamity spread by telegraph through the world, roused universal sympathy, and back, along the wires, as if by reflex action, came prompt offers of abundant assistance. The telegraph poured in reports of world-wide contributions in money, and the railway-trains came freighted with provisions, clothing, merchandise, and all the necessary supplies which a suddenly unhoused and bankrupted community might require. To meet these universal proffers of help, and carry out the work of distribution, the "Relief and Aid Society" was called suddenly into existence, and the present "Report" is the history of its experience. Its officers consisted of the ablest men in Chicago, and the record of their prompt and vigorous doings is in the highest degree interesting and instructive. The report they have issued is a model of systematic, detailed, and comprehensive statement of operations, and will be permanently valuable, both as an impressive chapter in the history of Chicago, and as a register of experiences that will be valuable for consultation in similar emergencies that are liable to happen in other cities. The volume before us is gotten up in superior style, but we hope there is a cheaper edition for general circulation.

The Doctrine of Descent, and Darwinism. By Oscar Schmidt, Professor in the University of Strasbourg. With Illustrations. 334 pages. Price, $1.50. D. Appleton & Co. No. XIII. of the "International Scientific Series."

A popular exposition of the general doctrine of Development and Descent, within moderate limits, has been long wanted. Mr. Darwin's works are voluminous, and they elaborate special points with a minuteness of detail and a wealth of learning that are the delight of the student, but are not attractive to the general reader. A compend of the main facts and essential logic of his system, as now widely accepted by naturalists, is therefore a desideratum in scientific literature. Various attempts have been made to meet this need, but they have generally been defective in statement, and made by men who did not know the subject at first hand. Prof. Schmidt's volume fairly covers the ground, and is brought within convenient limits for the general reader; while its author is an independent investigator in natural history, and has made his own original contributions to the theory which his book explains. As a piece of exposition the volume is quite remarkable, and its writer may be congratulated for having done his part toward relieving German men of science from the imputation recently intimated by Helmholtz, that they are behind those of other countries as lucid and successful popular teachers. There are a meatiness and a density of thought in this little work which betray the close German thinker, and keep the reader well occupied; but there are a wit, point, and polemical force in his pages, that relieve them from dryness, and well sustain the reader's attention. Yet the characteristic of the volume is that the author has seized the essential points of the great argument, and brought out, with unexampled success, the strength of what may be called the Darwinian position. The broad philosophic doctrine of Evolution he does not attempt to discuss, but limits his argument to the field of biology, to the Animal World in its Present State, the Phenomena of Reproduction, Historical and Paleontological Development, the Geological and Geographical Distribution of Life, Heredity, Reversion, Selection, Derivation, and Pedigree. An able chapter is given to Special Creation and the Nature of Species; the Bearing of Linguistic Inquiry upon the Doctrine of Development is presented; and the concluding chapter is devoted to the question of the Descent of Man. On all these subjects the author is up to the latest results, and presents them in a well-methodized form.

This volume covers very important ground in the popular scientific series to which it belongs, as its doctrines are sometimes implied and frequently referred to in the other books, and it is therefore satisfactory to know that Prof. Schmidt has executed his work with judgment and ability.

Religion as affected by Modern Materialism. By James Martineau, D. D., LL. D. With an Introduction by the Rev. H. W. Bellows. 68 pp. Price, 75 cents.

Dr. Martineau is one of the most affluent and captivating of modern theological writers, and is regarded as perhaps the leading English champion of Unitarian heterodoxy. His "Essays, Philosophical and Theological," reprinted by the Putnams, range over a wide variety of topics, and display much acuteness and logical force, but their chief characteristic is the imaginative raciness of their style. The essay now issued, and which was delivered as an address before the Manchester New College, is a brilliant rhetorical polemic, called forth by Tyndall's address, in which the author aims to expose what he regards as the inconsistency, the baselessness, and the absurdity, of modern materialistic philosophy. Many of his hits are fine, and many of his sarcasms biting, and the whole discussion is most readable, but we think the author leaves the subject very much as he found it. We fail to see that his breadth and liberality give him any advantage in *this* discussion over the narrow and bigoted theologian. As an historical fact, theological doctrines have stood in the way of Science at every great step of its advancement. Nor have the theologians ever consented to take their doctrines out of the way; the disagreeable duty has been imposed upon Science, all along, of displacing them. Nor does there seem to be yet, on the part of theologians, much disposition to change their tactics; they still plant down their dogmas in the pathway of investigation, and then denounce the antagonism of science, and the aggressiveness of its cultivators—because they will hold to their old course and drive on. In the present phase of the conflict, it is insisted upon, with a strange perversity, that Science is somehow the rival of the Deity; that what Science gains, the Creator loses. To the vulgar religious mind, thunder and lightning were formerly regarded as the immediate displays of Divine power and intervention in the management of earthly affairs, and, when Science affirmed that it could discern the promise and potency of these effects in matter, the ignorant theologian protested that God was in this way expelled from so much of his universe. Science has thus been interpreted as driving him out of sphere after sphere, until at last only a corner of the universe remains where the operations of the Divinity can be seen, and that is the realm of life. Prof. Tyndall now comes forward and says that he sees also in matter the promise and potency of every form of life, and the cry is raised that this is the final audacious aggression of Science, which drives the Divinity from the universe, and lands the human mind in scientific materialism and scientific atheism. If we understand Dr. Martineau, he holds this position in common with the narrowest of the orthodox. Yet there are many divines who see that the whole course of theology in this respect has been wrong, and that, rightly viewed, every successive step taken by Science, in conquering the world to the laws of order, has only strengthened and exalted the true view of the Divine government of the world.

Three Essays on Religion. By John Stuart Mill. 302 pp. Price, $2.50. New York: Henry Holt & Co.

The three elaborate essays which constitute this work are on the following subjects: I. Nature; II. Utility of Religion; III. Theism. The first two of these were written some twenty years ago, the last within half a dozen years; but Miss Taylor, the editor, in her "Introductory Notice," says that Mr. Mill intended to publish the essay on Nature—one of the first written—in 1873. From this it would appear that the views upon religious subjects which Mr. Mill entertained a quarter of a century ago were those that he continued to hold during life; indeed, Miss Taylor says that "it is certain that the author considered the opinions expressed in these different essays as fundamentally consistent;" and she adds, "It is apparent that his manner of thinking had undergone no substantial change."

Now, whatever Mr. Mill wrote upon subjects that had engaged his long and earnest attention was always valuable and worthy of thoughtful perusal; and, certainly, his reflections upon so universally important a matter as religion are entitled to grave consideration. And yet Mr. Mill's claim to be heard rests only upon the broad presumptive ground of his acknowledged greatness as a thinker, and our interest to know what he said is much the same as it would be in the views of Plato, Averroes, or Kant. For, as a thinker, Mr. Mill is already historic—historic not merely in the sense that he is dead, but that he is separated from the present by a great epoch of change in the philosophic view of Nature, and as belonging to an old dispensation of thought. As we have shown before, Mr. Mill virtually antedated the scientific era. He was educated in the most despotic manner, and with no more reference to science than if that agency had not appeared in human affairs. His whole discipline and mental furniture, although thorough and full, were on a method that had been perfected before science arose; and it was natural, if not inevitable, that his philosophic opinions on the subject of Nature and religion should have been in substantial harmony with the old skeptical school. Many questions are undoubtedly handled with originality and power; but the standing-point from which the whole subject is considered belongs to the last century.

That this stand-point has been greatly altered within a few years, so as to give new aspects to old religious problems, can hardly be doubted. The doctrine of evolution, which has latterly come forward so prominently, is not merely a theory of the origin of animal diversities; it is nothing less than a philosophy of Nature, and gives a new complexion to the great religious questions in which the interpretation of Nature is involved. Our space will not allow us to go into this inquiry, but the case was so well stated, the other day, in relation to Mr. Mill, in the editorial columns of the *New York Times*, that we cannot do better than to quote a passage or two from the article. The writer says:

"Much as Mr. Mill had labored in the field of modern metaphysics, he was by no means so familiar with the modes of reasoning of modern science. Had he been more so, he could never have indulged in his irreverent and almost flippant objections to the perfection and the ends of the workings of Nature. Nor would he have been so confident of the tendencies in Nature toward pain and degeneracy. The truth is, to the modern natural philosopher Nature is by no means so simple a machinery, or collection of guided forces, as it was to the investigator even twenty years since. Darwinism has changed all that. The simplest results in natural phenomena are plainly the effects and balancings of countless forces and forms of life, perhaps through millions of ages. The aspect and features, for instance, of a summer field—its flowers, insects, shrubbery, and animals, the soil and rocks and contour, the very hue of the flowers and the color of the insects—every simple phenomenon in it is the result and final balance of struggling forms of life and opposing forces, which must have been working under a guiding hand to produce this effect for '*eons* of *eons*.' The philosopher who should say that this did not show contrivance, or the perfection he expected, or that this complicated machinery suffered from jars, friction, and defects, would now, in the judgment of the most skeptical scientific men, be like a savage criticising the machinery of a steam-engine or the operations of a Babbage counting-machine. The matter is too complicated for any human observer to form any intelligent opinion upon. He neither sees the beginning nor the end. He is not certain that he can trace out a few threads of the intertwined web, even for a short distance. His best theory, that of 'the survival of the fittest,' is only a negative theory. It shows why forms of life are destroyed, but never 'the origin of species.' The only thing which a philosophical observer can do with any reason is to observe, during the short space of human history, *the drift of things*. Now, modern science, whether it be correctly based or not, is singularly opposed to Mr. Mill's pessimism in this.

"According to Darwinism, at least (which Mr. Mill certainly would recognize as a good working hypothesis), there is nothing in the universe existing or created for pain alone. Every instrument of destruction or torture —the claws of the tiger, the sting of the hornet, the venom of the rattlesnake, the teeth of the shark, the beak of the hawk— are not designed, or have not arisen, to give pain without purpose. They are all originally means of defense, or means of gaining sustenance, or weapons of attack in the struggle for food, or variations of harmless organs. Pain is incidental to them. And pain, in the Darwinian theory, is never an object *per se*, except as it tends to improve the subject. We are not now defending this theory of the universe; we only urge that modern science, on which Mr. Mill so confidently rests, does not present us with a universe where pain is the apparent object of creation, or where it has no useful ends.

"Moreover, Mr. Mill would be surprised to find that under the Darwinian hypothesis there is no degeneracy of the world, no drift toward the worst. Nature, to the Darwinian, is by no means so black as the elder and younger Mills paint her. According to the development hypothesis, there is an eternal progressive movement through the whole universe toward higher forms of life; in other words, modern science believes in necessary and ever-continuing advance. But a current toward the Best, a plan of the Cosmos which points toward perfection, a drift in the direction of what is complete, a movement like that of the stars of heaven, continuing slowly but surely through countless millions of ages, toward one centre of the universe—the perfectly Good—is surely one of the grandest of all indications in natural theology of a benevolent and perfect Creator. And for an observer, who has but a moment's time for observation, to criticise the movement because it is slow, reaches the height of irreverence and conceit."

The Elements of the Psychology of Cognition. By Robert Jardine, B. D., D. E. Sc. Macmillan & Co. 289 pp. Price, $2.

This volume has nothing marked about it that calls for attention. It belongs to a class, already numerous, which purport to be introductions to the study of the human mind. It is metaphysical in its method, and old in its inculcations. While the author designs it "principally for the use of students" who are beginning their philosophical studies, he confesses to another purpose, as follows: "The writer is ready to admit that one principal object which he kept before his mind in the preparation of the book, was to show the inadequacy and unsatisfactoriness of a prevailing system of psychology which may be indicated by the word phenomenalism." By phenomenalism we suppose he means corporealism, or the psychology which takes organic conditions into account in studying mental effects. But he "shows the inadequacy" of that method chiefly by ignoring it, and if disembodied spirits want a text-book of psychology adapted to their circumstances, the present work may be recommended to them as so well suited that it would not need revision to free it of any sublunary dross.

The Influence of Music on Health and Life. By Dr. H. Chomet. Translated from the French by Mrs. Laura A. Flint. 242 pp. Price, $1.25. G. P. Putnam's Sons.

An elegantly-printed little volume, with an attractive title, which is suggestive of a most interesting class of scientific questions. But the contents of the book are sorely disappointing. The questions we expected to meet are not considered, and the little science there is is bad. In a chapter devoted to "The Nature and Origin of Sound," the current physical explanation of the phenomena is rejected, and a sonorous or musical fluid is resorted to. The author says: "Why do not all the extended cords of a musical instrument, such as a piano, violin, violoncello or guitar, repeat together the tone or cry of the voice which utters sounds above them? Why, of all the cords of the same instrument, do those only which are in unison with this voice produce sound? Did not the noise, the sound, the sonorous wave, as they choose to call it, which escapes from the mouth, strike, disturb, and agitate all the strings? Yes, but the sonorous fluid did not find all of these its *Leyden jar*, nor in any the capacity for being charged with the sonorous fluid. This, I think, is the explanation of the phenomenon that can never be explained by the theory of the molecular vibration of the bodies, or of the undulations of the air." Where such crude notions are entertained, we cannot expect a very refined analysis of the relations of music to the nervous system; nevertheless, the volume contains a good deal of information in which the lovers of music may be interested.

Tables for the Determination of Minerals by those Physical Properties ascertainable by the Aid of such Simple Instruments as every Student in the Field should have with Him. Translated from the German of Weisbach. Enlarged and furnished with a Set of Mineral Formulas, a Column of Specific Gravities, and one of the Characteristic Blow-pipe Reactions. By Persifor Frazer, Jr., A. M., Assistant Geologist of the Second Geological Survey of Pennsylvania, lately Professor of Chemistry in the University of Pennsylvania. 117 pages. J. B. Lippincott & Co. Price, $2.00.

This is a very valuable little hand-book for the student of practical mineralogy, and an immense amount of careful and accurate information has been condensed into its pages. It grew out of the necessities of practical teaching in the school of Freiberg, and has been revised and adapted for use in this country by an experienced American geologist, and it is a guide to practical work which every student of minerals will find indispensable. The method of study to which it is tributary is thus indicated in a passage from the translator's introduction:

"Every one who has had the good fortune to study at the Royal Saxon Mining Academy, in Freiburg, will bear witness to the efficacy of the system there pursued for instructing young students in the art of distinguishing mineral species on the spot, by the aid of a tolerable memory, and an intelligent observation of a few of their most striking physical properties—both brought to the highest point of perfection of which they are capable by judicious cultivation, and kept in their best condition by assiduous daily exercise.

"The method of practical instruction pursued there, and which has been introduced by Freiberg graduates into many schools in this country, requires merely a cabinet of unlabeled minerals, and a professor who can determine—not one who has *learned* them. Each student, of a class of ten or more, places a tray of such minerals before him, and occupies the two hours devoted to "Praktische Uebung" in discovering, by the aid of the knife, the streak-tablet, the file, and the magnifying-glass, the true nature of as many of these minerals as possible. There is, however, a large class of minerals (the silicates, etc.) which, unless distinctly crystallized, present considerable difficulties to the field-worker. To partly overcome these difficulties, the supplementary tables were added by Prof. Weisbach, whereby, through the instrumentality of a bottle of acid, a matrass, a blow-pipe, and a couple of fluxes, a still larger number of species can be identified."

Polarization of Light. By William Spottiswoode, F. R. S., LL. D. 129 pp. Price, $1.00. "Nature Series." Macmillan & Co.

Dr. Spottiswoode is equally well known in the scientific and business world: in the scientific world as a mathematician, physicist, and member of the Royal Society; in the business world as printer to her Majesty, and the proprietor of an immense book-manufacturing establishment. The excellent little volume which is just produced on one of the most difficult departments of optics is, in a certain sense, the product of both the activities in which the author is engaged. It consists of lectures delivered at various times to audiences of the working people in his employ. In these lectures Mr. Spottiswoode attacked the most complex part of optical science, and one which it has hitherto proved most difficult to expound satisfactorily in a book; but, by the profuse employment of experiments, the lecturer was probably able to bring the subject within the range of his listeners' comprehension—its striking phenomena, at all events, if not their completest explanation. In this little volume the text is as clear as is consistent with extreme brevity, and the numerous well-executed woodcuts are valuable helps to the understanding of the subject, and will go far to replace the experiments which were made with the instruments represented.

Outlines of Proximate Organic Analysis. By Albert B. Prescott, Professor of Organic and Applied Chemistry in the University of Michigan. 192 pages. New York: D. Van Nostrand. Price, $1.75.

The science of chemistry is growing into immense proportions, and with its enormous expansion there comes a revolution in its theory of so radical a nature as to bewilder the old students, and raise a serious question how the prodigious mass of facts and details is ever going to be got into any thing like rational order. But, while Theory is perplexed, Practice proceeds with but little disturbance; only, as the field extends, division of labor has to be carried farther, and the more special departments of science are increasingly cultivated. The present work appears in obedience to this tendency, and furnishes a hand-book for a branch of analysis of no small importance, and which has hitherto hardly had its proper share of attention. The author remarks in his preface:

"Proximate organic analysis is not altogether impracticable, and organic chemistry is not solely a science of synthetical operations, even at present. It is true, as the chief analytical chemists have repeatedly pointed out, that in the rapid accumulation of organic compounds, the means of their identification and separation have been left in comparative neglect. It is true, also, that the field is limitless, but this is not a reason for doing nothing in it. Fifty years ago, the workers in inorganic analysis were unprovided with a comprehensive system, but they went on exploring the mineral kingdom, and using their scanty means to gain valuable results."

Researches in Acoustics. By Alfred M. Mayer. Paper V.; from the *American Journal of Science and Arts.*

Though but a pamphlet of 42 pages, it contains seven papers, each giving good, solid, original work on a difficult subject. Prof. Mayer has of late made acoustics a special field of investigation, and has given to science some admirable results.

Metallurgical Properties of Missouri Iron-Ores, from the Geological Report of the State of Missouri, 1874. By Adolf Schmidt, Ph. D.

This document is devoted to the metallurgy of iron. It specifies six ores in Missouri; gives their respective characteristics, and tabulates the quality of the iron when produced by smelting with charcoal, and coke, or coal, for the four irons technically known as foundery-iron, mill-iron, Bessemer-iron, and steel-iron. As a contribution to economical geology, it is valuable.

Half-Hour Recreations in Natural History. Boston: Estes & Lauriat. Pp. 31. Price, 25 cents.

This is Part III. of Mr. Packard's series, "Half-Hours with Insects," which we have already mentioned in the Monthly. The author here considers the relations of insects to man. Of course those insects which live by preying on human kind receive special attention. We do not remember ever before to have heard that the *Cimex*, or bedbug, is originally a parasite of birds, especially doves and swallows. "The opinion," says Prof. Packard, "that the bedbug originally lived under the feathers of semi-domestic birds is strengthened by the fact that a European species of *Cimex* lives on the body of the swallow, another on the bat, while a third is found in pigeon-houses." Insects that are of service to man are also considered, and, singularly enough, we find in this category the cockroach, which, instead of being the unmitigated nuisance generally thought, is the mortal foe of the bedbug, and really does good work in ridding our houses of that disgusting pest. The pamphlet is full of useful information, and is well illustrated.

Community of Disease in Man and other Animals. By W. Lauder Lindsay, M. D. Pp. 37.

The author of this little essay was laughed at by eminent medical authorities in Edinburgh, when, some twenty years ago, he ventured publicly to affirm that certain human diseases may be artificially produced in the lower animals. Things have changed since then, and the identity of various diseases in man and animals is now admitted. Nor is this true of physical diseases only; Dr. Lindsay has found that the lower animals, or at least some of them, not only possess mind resembling that of man, but are subject to the same classes of mental disorder, produced by the same predisposing and exciting causes. The work before us gives a long catalogue of bodily and mental maladies that are known to be common to man and animals. The list includes typhus, yellow fever, puerperal fever, gout, hysteria, mania, idiocy, goitre, asthma, quinsy, and Bright's disease; and he shows that various poisons affect animals in the same way as they affect man.

Metamorphism produced by the Burning of Lignite-Beds in Dakota and Montana. By J. A. Allen. Pp. 19.

This paper is reprinted from the "Proceedings of the Boston Society of Natural History," 1874. The *quasi*-volcanic metamorphisms of which it treats are singularly interesting, and here for the first time adequately described. In the "Bad Lands" of the Upper Missouri there exist highly-metamorphosed beds of clays and sands, accompanied by pumiceous and lava-like materials, which closely resemble volcanic products. Still the efficient cause was simply the burning of the underlying beds of lignite. Over hundreds and even thousands of square miles the evidences of these fires are to be seen in the mountain-ridges and buttes. There are frequent indications of the bursting through of these subterranean fires to the surface. Thus we find multitudes of jagged, chimney-like mounds of volcanic brescia. These were little volcanoes, having their seat of action in the burning coal-seam, ten, fifteen, or perhaps fifty feet below. The paper is one of rare value.

A Ramble round the World. 1871. By M. Le Baron de Hübner. Translated by Lady Herbert. New York: Macmillan & Co. 657 pages. Price, $2.50.

Excursions round the world are now made with such facility and regularity that the number of those who undertake them is rapidly increasing, while the variety and vivid contrast of the traveler's experiences, as he passes from continent to continent, offer an equal temptation to edify the stay-at-homes with a book describing the tour. A definite round-the-world literature of travel may thus be expected to grow up, and if it all proves to be as pleasant and instructive as Baron de Hübner's book, there will be no reason for regret. The present work is, however, more than an ordinary narrative of observation and traveling adventure. Its author, an Austrian nobleman, a man of culture and with wide experience of character, manners, and institutions, travels as a thinker, as well as a looker-on, and gives to his pages something of the insight of study as well as vivacity of narration. Of course it is impossible to go round the world in eight months and see through every thing, and sum up the philosophy of governments, races, and civilization, within the limits of a single portable volume. Baron de Hübner does not attempt this, but he has the faculty of seizing the most important features of the subjects considered, and his reflections are always sensible and suggestive, and often acute and valuable. His work is divided into three parts: I. America; II. Japan; III. China. To the first part he devotes twelve chapters, and to Parts II. and III. each eight chapters.

The author tells us that the objects of his journey were "to behold, beyond the Rocky Mountains, in the virgin forests of the Sierra Nevada, civilization in its struggle with savage Nature; to behold, in the Empire of the Rising Sun, the efforts of certain remarkable men to launch their country abruptly in the path of progress; to behold, in the Celestial Empire, the silent, constant, and generally passive, but always obstinate, resistance which the spirit of the Chinese opposes to the moral, political, and commercial invasions of Europe."

The Voice in Singing. Pp. 192. The Voice in Speaking. Pp. 164. Translated from the German of Emma Seiler. Philadelphia: J. B. Lippincott & Co. Price, $1.50 each.

The author of these volumes, a trained artist in vocal music, attempted to give instruction in that art, but found that the usual methods consist simply of empirical formulas, without any thing like scientific coördination. Accordingly, she undertook to discover for herself a rational method of instructing pupils. While Helmholtz was accumulating material for his great work, "Tonempfindungen," she became his pupil, and, to some extent, his collaborator. The result is these two volumes, which, in the words of Du Bois-Reymond, show an "acquaintance with all the facts and theories concerning the production of the human voice."

On the Habits of Some American Species of Birds. By Thomas G. Gentry. October, 1874.

These observations extend through four seasons, and are limited to Pennsylvania. The explanation why the cow-bird's egg hatches first in the nest of smaller eggs where it is clandestinely placed by the parent, is ingenious. The egg being larger than the others, is pressed upon by the incubating bird, hence it gets the most heat from the bird's breast. In descriptive ornithology science abounds, but, in recording the life-traits of birds, too little has been done, hence the peculiar value of this contribution.

Nomenclature of Diseases, prepared for the Use of the Medical Officers of the United States Marine-Hospital Service. By the Supervising Surgeon, John M. Woodworth, M. D. Washington: Government Printing-Office. Pp. 210.

This is a reprint of the "Nomenclature of Diseases" drawn up by a joint committee appointed by the Royal College of Physicians, London. Its republication is intended to aid in promoting the acceptance of a common nomenclature among the medical profession in all English-speaking countries.

The Foes of the Farmers: an Address delivered at Omaha, October 1, 1874, during the Nebraska State Fair, by Prof. A. L. Perry.

The foes herein discussed are "paper money, protective tariffs, and party spirit." Though approving the object of the Grange movement, the professor dislikes its secrecy. With a good deal in it that is somewhat *ad captandum*, such as "greenback-grasshoppers are worse than any other kind of grasshoppers," the address is an able tract on political economy as affecting the farmer's interest.

An Elementary Treatise on Steam. By John Perry, B. E. New York: Macmillan. Pp. 424. Price, $1.50.

This work is adapted to the use of students acquainted with algebra and familiar with at least the simple definitions of trigonometry and the elements of physics. It is published as one of a series of "School Class Books;" but who expects to receive theoretic or practical knowledge of steam at any "school" whatever? As a manual for the earnest student, who has access to steam-engines and steam-driven machinery, the work is valuable. It is divided into four sections, whereof the first treats of heat, the second of steam-engines and boilers, the third of locomotives, and the fourth of marine-engines.

Bulletin of the Minnesota Academy of Natural Sciences for 1874. Pp. 108. Price, 50 cents.

It is gratifying to receive so substantial an evidence as this of the progress of science in the more recently-settled portions of our country. The titles of the papers in the present number are: "Birds of Minnesota," by Dr. P. L. Hatch; "Mammalia of Minnesota," by Dr. A. E. Ames; "Report of the Curator of the Museum;" "Prerequisites to a Proper Study of Science," by Dr. Charles Simpson; "Minnesota Geological Notes," by N. H. Winchell; "Antiquity of Man," by Dr. A. E. Johnson; "Astronomy—Scientific and Unscientific," by G. W. Tinsley.

Archives of Dermatology: a Quarterly Journal of Skin and Venereal Diseases. Edited by L. Duncan Bulkley, M. D. New York: Putnams. $3.00 a year.

This is a new periodical, and as a "first number" the specimen before us is excellent. The *Archives* has no rival on this side of the Atlantic, and this circumstance, taken in connection with its intrinsic worth, ought to insure its success. Besides original communications, of which the present number contains six, the *Archives* will contain the Transactions of the New York Dermatological Society, clinical records, a digest of the current literature of dermatology, reviews and bibliography, and editorials.

The Protoplasm Theory. By Edward Curtis, A. M., M. D. Pp. 23.

Dr. Curtis is Professor of Materia Medica and Therapeutics in the New York College of Physicians and Surgeons, and this is his introductory lecture for the winter course of 1873. It is an able argument for the oneness of the physical basis of life throughout the organic world. Though the lecture was originally addressed to medical students, it nevertheless may be read understandingly and with profit by the lay public.

Organic Chemistry. By W. Marshall Watts, D. Sc., F. C. S. New York: Putnams. Pp. 130. Price, 75 cents.

The primary aim of this little manual appears to be, to fit students for passing the examinations of the English "Science and Art Department." In so far as the book discusses its subject-matter proper, viz., the chemistry of the carbon compounds, it is as full and explicit as could be expected, considering its size.

Report upon Ornithological Specimens collected in the Years 1871, 1872, and 1873. Pp. 148.

Catalogue of Plants collected in the Years 1871, 1872, and 1873. Washington: Government Printing-Office. Pp. 62.

These valuable Reports form a part of the published work of the geographical and geological explorations under the charge of Lieutenant Wheeler. The Ornithological Report is by Dr. H. C. Yarrow, and has been revised and corrected by Robert Ridgway, of the Smithsonian Institution. The Catalogue of Plants is by Mr. Sereno Watson and Dr. J. T. Rothrock.

MISCELLANY.

The Cause of "Cold Snaps."—In a paper read before the American Academy of Science, Prof. Loomis offered a new theory to account for sudden falls of temperature, or "cold snaps," as they are called. The usual mode of accounting for these is by supposing that a current of cold air sets in from the north. A laborious investigation of the subject has led Prof. Loomis to the conclusion that these low temperatures, which occur at irregular intervals in every month, and particularly during the winter, are due mainly to the descent of cold air in the neighborhood, and that this descent of air results from the outward movement, which generally takes place from the centre of an area of high barometer. The theory is fully sustained by observations. As for the opposite theory, if the cold comes to us from the north, "whence does it come," asks Prof. Loomis, "to these colder known points on the earth's surface?" In summer, during a thunder-storm, the temperature often falls 10° in a few minutes, but observations show that there was no air-current from the north. These sudden gusts of cold must descend from the higher atmospheric regions.

School Hygiene.—Dr. Richard Liebreich, the eminent oculist, read a paper on "School Hygiene" at a recent meeting of the London Social Science Association. He spoke of the influence of the posture of children during school-time, restricting himself to the discussion of two points, namely, short-sightedness and lateral curvature of the spine. Short-sightedness, he said, is produced by the lengthening of the antero-posterior axis of the eye, by the increased tension of the apparatus with which we adapt our eyes to different distances. The tension is stronger in proportion as the distance is shorter to which the eye is adjusted. If this power is made use of for adjusting the eye continually to a much shorter distance than would be required; i. e., if, in reading or writing, the eyes, instead of at twelve to fifteen inches, are kept at four to six inches' distance from the book, the sclerotic, or membrane which keeps the globe of the eye in shape, giving way by degrees to the pressure, gradually extends antero-posteriorly. Thus the eye becomes oval, and the retina is somewhat removed from the optic media, from the cornea, and the lens. The retina then only receives the images of near objects; distant objects appear undefined, and can only be seen by the aid of concave glasses.

The abnormal posture of children during school-time, and especially while writing, is productive of spinal curvature. Pupils are forced every day, for several hours, to maintain the same unhealthy posture, overtiring always the same muscles, twisting and bending the spine always at the same place, and thus gradually altering the shape and position of the bones. The normal position would be to keep the upper part of the body straight; the shoulder-blades, both of the same height, freely suspended, together with the upper arm, on the ribs, and in no way supporting the body; both elbows on a level with each other, and almost perpendicular under the shoulder-joint, without any support; only the hands and part of the fore-arm resting on the table; the weight of the head freely balanced on the vertebral column, and not on any account bent forward, but only turned so much round its horizontal axis that the face may be inclined sufficiently to prevent the angle at which the eye is fixed on the book from being too pointed.

Dr. Liebreich then presents the following design for school desks. The top of the desk has an inclination of 20° for writing; for reading, a greater inclination is required—about 40°. This latter is obtained by turning up a flap of five inches in width, fixed to the front edge of the desk. All seats have backs, consisting only of a board three inches wide, which, placed at the right height, sufficiently supports the lower joints of the spine, to enable the pupil to keep straight while reading or writing. The distance between the back of the seat and the table can be regulated to the size of the pupils, and is always just sufficient for the flap to come quite near the child when writing.

Floating of Solid in Molten Iron.—In a communication to the *American Journal of Science*, Prof. Adolf Schmidt takes exception to Mr. R. Mallet's explanation of the phenomenon of certain metals in the solid state floating upon a bath of the same metals in a molten state. Mallet assumes the existence of what he terms a "*repellent force.*" Prof. Schmidt upsets this assumption by an experiment which he thus describes: "Have a solid ball of cast-iron of one and a half to two inches diameter cast and filed off pretty smoothly. Have a ladle or vessel of at least three-quarter cubic foot capacity filled with molten cast-iron. If, then, you lay the cold cast-iron ball on the surface of the molten iron, you will find that the ball, in spite of the 'repellent force,' assumed by Mr. Mallet, will sink to the bottom of the ladle at once. With an iron rod you can feel the ball at the bottom of the ladle, and roll it about. But, after twenty or thirty seconds, the ball will slowly rise to the surface of the bath and remain there. It is thus evident that cast-iron, at ordinary temperatures, is both *heavier* and *denser* than molten iron, but that, as its temperature rises, the solid iron expands, and becomes lighter, and finally floats on the molten iron. The latter fact shows simply that solid iron, when at a high temperature, approaching its melting-point, is less dense and lighter than molten iron, which fact again implies that molten iron must undergo a rapid expansion in the moment of its solidification. The extent of this expansion is, however, less than that of the subsequent contraction in cooling, so that the cold iron is again denser than the molten iron."

Growth of Plants within the Egg.—Prof. Panceri's observations and experiments on the production of cryptogamic vegetation in eggs are interesting, from their bearing on the question of spontaneous generation. At Cairo, an ostrich-egg was given him which was still fresh, the air-space having not even been formed. He soon, however, noticed the appearance of dark blotches within the shell, and, having broken it to ascertain the cause, he found that they were produced by the growth of minute fungi. The partisans of spontaneous generation look on such cases as that as an argument in their favor, supposing the shell of an egg to be quite impermeable to germs derived from without. Panceri, on the contrary, has found that the unbroken shell of an egg is permeable to liquids, and that these may introduce germs into the interior. He has, in fact, actually inoculated uncontaminated eggs with a fungus obtained from the interior of one in which it had made its appearance in a way seemingly so mysterious, and which he had cultivated in egg albumen.

Huxley on the Cell-Theory in Physiology.—In seconding a motion of thanks to Prof. Redfern, President of the Biological Section of the British Association, Mr. Huxley said that the promulgation of the cell-theory had as great an effect upon the physiological world as the French Revolution had on the world of politics. Referring to the doctrine promulgated by Schwann and Schleiden, he said that underneath that doctrine there lay the idea which had been established by every further observation, and which remained unassailable, viz., that the living body was not a simple continuous whole, and its action was not the action of a unity, but that it was made up of a multitude of parts, which lived a *quasi*-independent life; and that the body of a man was made up of an enormous multitude of small living particles, each of which, though subordinated and kept together by means referred to by Prof. Redfern, led a *quasi*-independent life, as did the cells of the organic elements of a plant. It was, in fact, the application to animal-structure of the idea which had been previously applied to plant-structure.

The Deep-Sea Bottom.—In the "Preliminary Notes" of the Challenger Expedition, presented to the Royal Society of London by Prof. Wyville Thomson, are to be found some observations on the *Globigerina* and on the sedimentary formations at the bottom of the sea, which mark a substantial advance in the science of these subjects. The globigerina is a minute foraminifer, the shells of which constitute the great bulk of the chalk formation. An ocean sediment known as the "globigerina-ooze" also consists principally of these shells, and hence it is to be regarded as a true chalk formation. Hitherto Prof. Wyville Thomson and Dr. Carpenter have supposed that the globigerina is an inhabitant of the sea-depths, while other English, as well as American and German, naturalists have insisted that it is a surface animal. In these "Preliminary Notes," Prof. Thomson very frankly admits the erroneousness of his own view. In fact, the living globigerina is, he says, very different in appearance from the dead shells we find at the bottom of the sea. In the living animal the shell is clear and transparent, and each of the pores which penetrate it is surrounded by a raised crest, the crest round adjacent pores coalescing with a roughly-hexagonal net-work, so that the pores appear to be at the bottom of an hexagonal pit. At each angle of this hexagon the crest gives off a delicate, flexible, calcareous spine, sometimes four or five times the diameter of the shell in length. These spines radiate symmetrically from the direction of the centre of each chamber of the shell, and the sheaves of long, transparent needles crossing each other in different directions have a very beautiful effect.

The nature of the deposit at the bottom

of the ocean appears to depend upon the depth of the superincumbent water. So universally is this the case that the observers on board of the Challenger needed only to know the depth at any locality in order to foretell the character of mud that would there be brought to the surface by the dredging apparatus. According to Prof. Thomson, "the mean maximum depth at which the globigerina-ooze occurs is about 2,250 fathoms. The mean depth at which we find the transition gray ooze is 2,400 fathoms, and the mean depth of the red-clay soundings is about 2,700 fathoms." These three sedimentary formations, however much they differ from each other, are all the result of the precipitation to the bottom of the dead shells of the globigerina and other surface animals. Why, then, do they differ so much in appearance and in chemical constitution? The globigerina-ooze is 98 per cent. carbonate of lime; the gray ooze consists of carbonate of lime with a greater or less proportion of clay; the red ooze is almost pure clay, viz., silica, alumina, and red oxide of iron. Prof. Thomson accounts for the absence of carbonate of lime from the red clay, and its partial absence from the gray ooze, by the theory that at great depths there is an excess of free carbonic acid. This would convert the carbonate of lime of the shells into a soluble compound. In that case the red clay would be "the insoluble residue, the *ash*, as it were, of the calcareous organisms which form the globigerina-ooze after the calcareous matter has been removed." It is worthy of note that living animals, brought up by the dredge from great depths, have their calcareous shells very rudimentary.

A Ballooning Spider.—A paper of singular interest, by Dr. Lincecum, contributed to the Smithsonian Institution and published in the *American Naturalist*, describes the marvelous art of the gossamer spider in the construction and navigation of her aëronautical ships. In Texas, according to the author, December is the month for these ballooning spiders to emigrate. When they intend to make an ascension, they fix themselves on some extreme point of the branch of a tree, or weed, or corn-tassel, then carefully spin out a lock of white gossamer, five or six inches long and two inches wide in the middle, tapering toward the ends, holding it all the time in the gentle breeze by a thread two or three inhces long, which, being attached to the end of the selected point, detains the balloon until it is finished. They then spin out at the bow two lines, thirty or forty feet in length, and another of twenty or thirty feet at the stern, then cut the cable and sail away on an inclined plane. There are a mother and half a dozen or more young spiders aboard every balloon, and thus the species is scattered over vast districts. These tiny aëronauts choose for starting on their voyage a clear day, temperature 60° Fahr., wind gently from the south. At about 1 P. M. they may be seen sailing with the wind. Toward 4 P. M. the spectator will observe that the balloons are beginning to descend. When the streamers strike some tall weed or grass the air-ships are made fast and the passengers instantly leap out, spinning out a thread as they fall, thus landing in safety.

A Demand of Modern Education.—In an address delivered on the occasion of the dedication of Pardee Hall, the scientific school attached to Lafayette College, Prof. Rossiter W. Raymond made some timely remarks upon the absurdity of attempting to complete a young man's aducation in the same time now as fifty years ago. The enormously-increased demands of modern life, said Prof. Raymond, requiring as they do that a man shall know more things, and know how to do more things, than were formerly sufficient for his reasonable success, are not to be satisfied by a mere change in a few subjects of instruction. It is not enough to substitute one study for another. The period of study must also be prolonged. In recognition of this principle, while it is for the present impracticable to make it an invariable part of a college education, by imperatively increasing the length of the college course, or by raising the standard of admission to colleges, the device of a post-graduate course has been very generally adopted; and it will not be long before experience will demonstrate that those men who have received the most thorough preparatory training are able to overtake and to outstrip in the subsequent race of life those who started with half-developed powers and half-furnished minds.

Insects and Flowers.—In his lecture at Belfast, on "Common Flowers in Relation to Insects," Sir John Lubbock inquired into the causes of flowers closing their petals during rain, and of some flowers remaining open for a longer or shorter period than others. The habit of closing the petals during rain is obviously an advantage, since it prevents the honey being spoilt or washed away. Everybody, however, has observed that even in fine weather certain flowers close at particular hours. This habit of going to sleep is surely very curious: why should flowers do so; and why should some flowers close at the approach of night, and others not? Moreover, flowers keep different hours. The daisy opens at sunrise and closes at sunset, whence its name *day's eye;* the dandelion opens at seven and closes at five; ear hawkweed is said to wake at eight and go to sleep at two; the scarlet pimpernel wakes at seven and closes soon after two; while *Tropogon pratensis* opens at four in the morning and closes just before twelve, whence its English name "John-go-to-bed-at-noon." Other flowers, on the contrary, open in the evening. Now, it is obvious that flowers which are fertilized by night-flying insects would derive no advantage from being open by day; nay, it would be a distinct disadvantage, as rendering them liable to be robbed of their honey and pollen by insects not capable of fertilizing them. Hence the lecturer believed that the closing of flowers has reference to the habits of insects. In support of this, he observed that wind-fertilized flowers never sleep, and that some of those flowers which attract insects by smell emit their scent at particular hours.

Catching Cold.—We find, in the Detroit *Review of Medicine*, an account of Prof. Rosenthal's researches on the effects of sudden changes of temperature, from which we abstract a few very useful observations. It has long been known that "colds" are produced, not by lowness of temperature, but rather by sudden changes from a higher to a lower. The application of cold to the surface of a healthy animal causes the cutaneous vessels to contract, and then the blood is prevented from circulating in the skin, and confined to the interior of the body, where it does not readily lose its heat, but serves to supply warmth to the vital organs. But, if the animal be exposed to heat, the cutaneous vessels become dilated, and so remain after exposure to cold. The blood is thus exposed in large amount over a wide surface, and becomes rapidly cooled, even though the temperature of the surrounding medium is not very low. A sudden passing from a heated room into the cold outer air rapidly cools the blood below the normal degree. As it returns to the internal organs, it cools them much more quickly than it would have done were not the vessels dilated by previous warmth. Thus a *sudden* cooling of the blood produces an irritating effect, or induces inflammation in a way that a *gradual* alteration would not do. To produce evil results the cooling must be from *above* to *below* the normal temperature. The effect of a chill in causing inflammation may be due partly to the effect of cold on the tissues themselves, and partly to the congestion (hyperæmia) which will occur in some parts when the fluid is driven out of others by the contraction of vessels. Rosenthal lays most stress on the former of these effects. It is a well-known fact that frequent cold bathing or sponging enables one to bear with impunity sudden changes of weather. This is explained by the improved tone of the vessels, produced by the cold applications. Thus, when exposed to heat, they are not so relaxed that they cannot sufficiently contract when necessary.

How Plants are distributed.—Some low ground on the banks of the Delaware, below the city of Philadelphia, having had a quantity of mud from the channel of the river spread over it, two species of plants, *Polygonum Orientale* (an East Indian species), and *Cleome pungens* (a West Indian species), soon made their appearance in great numbers. During a discussion, in the Philadelphia Academy of Sciences, as to the probable origin of the seeds of these plants, Dr. Leidy expressed the opinion that as the ground had long been used as a place of deposit of ships' ballast, the seeds might have been in the ground previously, and been quickened by the deposit of the mud. Mr. Meehan thought that perhaps the seeds of these plants, protected from air while buried under water, might germinate after exposure to the air. He referred to other cases of the springing up of new plants after the deposit of fresh earth, and suggested a mode of testing the origin of the seeds.

Education and Invention.—There exists a very general belief that great inventions usually come from uneducated men. How erroneous this belief is, at least as regards the art of metallurgy, is well shown by Mr. G. F. Becker, in a lecture delivered in the College of Mines, University of California. Nasmyth, for instance, invented the steam-hammer, without which neither the metallurgist could turn out sound masses of metal of sufficient size for the fabrication of the vast machines now in use for steamships and other purposes, nor the machinist forge them into shape. The crystallization process, and the zinc process for the desilverization of lead, not only enable us to extract at a profit very small proportions of silver and gold, but also produce an admirable quality of lead. Formerly the quality of lead used to depend almost entirely on that of the ore, and the best brands were exported to all parts of the world; now the best of lead may be made from almost any lead-ore. The inventor of the crystallization process, Pattison, was a professional assayer and metallurgist; and Karsten, who invented the zinc process, was a man of great learning and a metallurgist of the first rank. The inventor of the Rachette furnace, "the furnace of the present and probably of the future for lead or copper smelting," is the engineer who controls the whole governmental smelting and mining interests of Russia. Bessemer, the inventor of the process which bears his name, is a man of extensive scientific acquirements; and Siemens, whose most ingenious apparatus for producing very high temperatures has vastly increased our powers of heating iron and steel, of producing all grades of steel, and of distilling zinc, received as perfect an education, scientific and technical, as the world had to offer. It was Faber du Faur, an accomplished Bavarian metallurgist, who first made practical use of the gases which formerly escaped in immense quantities from the tops of blast-furnaces; and the enormous blast-engines, the hoisting-engines, pumps, and hot-blast stoves, often even the roasting-kilns of such establishments, nowadays require no fuel except this long-neglected waste product. Bischof, another engineer, and metallurgical author, was the first to produce gas artificially for smelting purposes; and this was one of the greatest advances ever made in metallurgy. Lundin, a thoroughly educated Swedish metallurgist, has shown how gas may be produced from wet saw-dust, of such power that wrought-iron may be melted with it.

The Temperature of Germination.—Herr F. Haberlandt has published three tables, showing the maximum and minimum germination temperature of all the more important agricultural seeds. He gives the minimum for by far the largest number, including wheat, barley, rye, oats, buckwheat, sugar-beet, linseed, poppy, clover, lucern, peas, rape, and mustard, as below 40.5° Fahr. The minimum for sainfoin, pimpinella, carrot, cumin, sunflower, *Sorghum saccharatum*, *S. vulgare*, and maize, is between 40.5° and 51° Fahr.; for tobacco and gourd, between 51° and 60.4° Fahr.; and for cucumber and melon, the minimum lies betweeen 60.4° and 65.3° Fahr. The second table shows the percentage of seeds germinating at the temperatures 61°, 47°, 88°, 100°, 110°, and 122° Fahr., and the number of hours elapsing before the rootlets reached a length of two millimetres (0.07874 inch). The maximum limit for coriander and marjoram is between 77° and 88° Fahr.; for wheat, rye, barley, oats, English ray-grass, vetches, horse-bean, peas, chick-peas, white-mustard, woad, cabbage, late kohl-rabi, turnip, radish, madder, fennel, carrot, cumin, parsley, poppy, linseed, tobacco, and anise seed, between 88° and 100° Fahr.; for the common bean, lupin, clover, lucern, early kohl-rabi, summer-rape, buckwheat, chiccory, sunflower, and some varieties of cabbage, between 100° and 110°; and finally, for maize, *Sorghum vulgare*, panic-grass, turnip-radish, hemp, teasel, gourd, cucumber, and sugar-melon, between 110° and 122° is the maximum. The third table shows the average growth of the rootlets in two days at different temperatures. In all cases there is increased growth from 61° to 77° Fahr.; in many cases, as grasses, clover, mustard, and linseed, a decrease from 77° to 88° Fahr., and in nearly all cases a decrease from 88° to 100° Fahr.

Poisoned Soils.—Trees have been twice planted in a certain square in London, but in both cases died. Dr. Voelcker was accordingly directed by the Royal Horticultural Society to inquire into the cause of this. On examining the clear, watery solution from treating the soil with distilled water, he found that the soil contained one-tenth per cent. of common salt, and two-tenths per cent. of nitrates. Whenever the amount of chlorine in soil has reached any thing like an appreciable quantity, it exercises an injurious influence. Land, for example, which has been inundated by the sea, will not grow wheat for the next two years, though in the first year cabbages may be grown, and they will withdraw a good deal of salt from the soil. The quantity of nitrates in the soil under examination was remarkable. Usually, this quantity does not reach a proportion that could be expressed otherwise than by a third place of decimals. There was no doubt, according to Dr. Voelcker, that the two saline ingredients mentioned did the mischief. He did not doubt that the presence of the salt and nitrates was due to the fact that the place was constantly used for committing nuisance. In the same way rabbits kill hedges, and it is well known that it is years before grass will grow in their runs.

Anæsthetics and Metaphysics.—Benjamin Paul Blood has written and printed a little book entitled "The Anæsthetics Revelation and the Gist of Philosophy." His idea seems to be that, when the nervous system is twisted out of its normal function by certain poisons, as it springs back great things are revealed; that is, at the moment a person escapes from anæsthetic stupor he gets a glimpse of the "genius of being"—whatever that may be. Mr. Blood wrote to Tennyson about his discovery, and in his reply the poet says: "I have never had any revelations through anæsthetics; but a kind of 'waking trance' (this for lack of a better word) I have frequently had quite up from boyhood when I have been all alone. This has often come upon me through repeating my own name to myself silently till all at once, as it were, out of the intensity of the consciousness of individuality, the individuality itself seemed to dissolve and fade away into boundless being—and this not a confused state, but the clearest of the clearest, the surest of the surest, utterly beyond words—where death was an almost laughable impossibility—the loss of personality (if so it were) seeming no extinction, but only true life."

The Black Death in Egypt.—According to a correspondent of the Paris *Journal des Débats*, writing from Egypt, Europe is threatened with a visitation of the black death. The pestilence is said to be spreading rapidly in the neighborhood of Medina and Mecca, its chief feature being the dreaded "plague-spot," which, once it appears, is the sure sign of a fatal termination. The Egyptian Government is exerting itself to the utmost to prevent the spread of the contagion; but, unfortunately, the Ramadan is at hand, when thousands of Mussulman pilgrims flock to the shrine at Mecca, and it is feared that they will not only help to spread the contagion there, but also bring it back with them to Europe. The greatest anxiety is felt in Italy, on account of its frequent intercourse with Egypt and the coasts of Asia Minor. The only means of averting the danger would be a stringent prohibition to the pilgrims to return direct to the country from which they came; but this measure would require the united action of the European governments, in order to gain the consent of the various Mussulman governments.

The "Voltaic Armadillo."—Regarding the medical use of this contrivance, a leading physician of New York writes us as follows: "I prescribed the voltaic apparatus of Mr. Seibert for one of my patients, a few weeks ago. I have not heard from my patient since, and do not know what effect, if any, resulted. Pulvermacher's chains, I know, have the indorsement of Sir Charles Locock and many other leading physicians of London; but I know nothing personally of their utility. I intend to try the 'Armadillo' again."

We spoke of the "Armadillo" last month, not from any direct knowledge we have of it, but to correct the advertised statement that The Popular Science Monthly had endorsed it, which was not true.

Address to an Atom.

BY AN UNCOMFORTABLY CONSCIOUS AUTOMATON.

Mysterious particle,
Intangible and most indefinite article,
Which even Science cannot fix or focus;
Are you indeed of all this hocus-pocus,
Mischristened Cosmos, protoplast? If so,
'Tis pity that the happy *status quo*
Of universal dumb inertia ever
Was broken up by vortices or voices.
'Twere surely better far that space had never
Reëchoed to objectionable noises,
Or witnessed all this pother
Of biologic bustle, whose chief law seems Bother!
Why could not you,
And all your fellow-motes, far, far too prankful,
In the embraces of the boundless blue
Rest and be thankful?
A plague on all your forces and affinities!
A mob of monads, to my notion,
Surpasses one of demons or divinities
Only while idle. With the earliest motion
Began the immitigable Mischief. Why
Must you in chaos cut those primal capers,
Which were "the promise and the potency"
Of—all the woes that fill our morning papers?
'Tis surely a reflection most unpleasant
To think that all the plagues which haunt the present
Spring from that moment in the hidden past,
When the first molecule, weary at last
Of immemorial motionlessness, stirring,
Jostled his neighbor Atom. What a whirring
Went through astounded space!
Thought pictures a grim grin upon the face
Of him, the Prince of Evil;
Only that then, of course, there was no devil.
At least of the New Creed that's one prime article;
Though I have little doubt
He was incipient in that self-same particle
Whose fidgets caused the first great stirabout.

If Science's "dry light," at its meridian,
Finds men no more than automatic midges
In its cold ray, the history that bridges
The space between us and the first Ascidian
Were better blotted.
To archetypal atoms was allotted
An easier fate than to the complex mass
Of "clever matter," which has dared to pass
For Man, but is, for all its prayers and panics,
A problem in molecular mechanics!
If Conscience be but chemic combination,
And Love a mere molecular affinity;
What boots all Life's superfluous botheration
Of mad and painful dreams, that limn Divinity
On fool-projected limbos? Life's a swindle,
If taken *à la* Tyndall.
And, let who may in that demoniac war win
("Survival of the fittest!")—yet, as groping
Less anxiously, less fearing, striving, hoping,
An Ape was less a dupe than is a Darwin.
That Atom must be a misguided duffer
Who'd join a Co.; *alone* it could not suffer.
Why should it long for partnership and pain so?
I would *I* were a monad—I'd remain so;
And as for "nascent thrills" and "ganglia," drat 'em!
They're things for which I should not care—an Atom!

NOTES.

To determine the real value of the "disease-proof potatoes" advertised by seedsmen, the Royal Agricultural Society of England, some time since, offered a prize of £100 for a really disease-proof potato. The conditions were that the potatoes should be tried in twenty different parts of the kingdom for three years. But the committee did not need to continue the experiment for three years; the results obtained in one season were decisive. None of the potatoes resisted the disease. During the period of vigorous growth, in five localities out of the twenty, the disease was virulent in all the varieties, and by the end of the season it had appeared in all the plots.

The collection of anatomical and physiological preparations made by the late Prof. Jeffries Wyman was in his will bequeathed to the Boston Society of Natural History, on condition that they paid to his heirs the sum of three thousand dollars. The Society promptly accepted the bequest; but, instead of the sum named in the will, of their own accord they paid to the heirs five thousand dollars.

From the investigations of Prof. Buckley, State Geologist of Texas, it appears that that State has vast deposits of iron and coal, of much greater extent than had been anticipated. Both are of excellent quality, and, in some cases, they occur near together. He has also found an abundance of salt, gypsum, and a wide range of copper-ores. Other valuable minerals are roofing-slate, marble, soapstone, etc.

Dr. Kosch, of Vienna, has discovered a method of making certain colors fire-proof, so that they may be used for painting on china in precisely the tones required. The inventor also employs a special enamel, which he spreads over the surface to be painted on, thus doing away with the irregularities and porosities of the porcelain; the irregular and undue absorption of color is thus prevented. Another invention of Dr. Kosch's is the fusion of gold, silver, and platinum, with bronze, by which the most gorgeous effects are produced.

A new method of casting statues in bronze has been discovered by a Venetian founder named Giordani. The advantage of the method consists in the cast being effected in a single operation, no matter how large the model, or how complicated in its form.

During the Paleolithic period horses were numerous all over Europe, and formed the basis of human food. In every "find" of that epoch, horses' bones constitute a considerable portion of the animal remains.

But in the next age, the age of polished stone, we find no indications of horse-flesh having been consumed as food. The question is, whether the horse disappeared from Europe just as it did from this continent, and was imported again from abroad.

A new mineral, Rivotite (so called in honor of the memory of M. Rivot, late of the Paris School of Mines) has been discovered by X. Ducloux. It occurs in small, irregular masses, dispersed in a yellowish-white chalk, upon the western slope of the Sierra del Cadi, in the Spanish province of Lerida.

Sugar, now almost one of the necessaries of life, was nearly unknown to Europe before the Crusades. At present, England consumes as much sugar as all the rest of Europe together—more than one pound per week for every man, woman, and child in the United Kingdom. In 1870, the refined cane-sugar, molasses, and syrup, manufactured in the United States was: Sugar, 754,000,000 pounds; molasses, 839,000 gallons; and syrup, 18,000,000 gallons.

A characteristic effect of snake-poison is rapid decomposition of muscular tissue. From Dr. Weir Mitchell's experiments it appears that, after a few hours, the wounded muscle becomes almost diffluent, and assumes a dark color and somewhat jelly-like appearance; under the microscope it has the appearance of a mass of minute granules.

The "Copley Medal" of the London Royal Society for the year 1874 has been awarded to M. Louis Pasteur for his researches on fermentation and on Pebrine (a disease of the silk-worm); the "Rumford Medal" to J. Norman Lockyer, for his spectroscopic researches on the sun and on the chemical elements; a "Royal Medal" to Prof. William C. Williamson, for his contributions to zoology and paleontology; and a "Royal Medal" to Henry Clifton Sorby, for his researches on slaty cleavage, and on the minute structure of minerals.

The British Government has decided to send out next spring an expedition to explore the region of the north-pole. The chief command of this expedition is to be intrusted to Captain Nares, at present in command of the Challenger and already a distinguished arctic navigator. It is intended to make the expedition a purely naval one, no person being permitted to join it in any capacity save officers and men of the Royal Navy.

Two German physiologists, Weiske and Wildt, in a series of investigations on goats, have shown that, although the withdrawal of lime or of phosphoric acid from the food of adult animals leads to fatal consequences, yet it has little or no influence on the composition of the bones, and in particular does not make them friable. To determine the same point with regard to young animals, they selected Southdown lambs about ten weeks old. One of these was fed upon food poor in phosphoric acid, a second on food poor in lime, and a third on normal diet. After the lapse of 55 days various bones were analyzed, and the general result was that, just as in adults, so in young animals: no remarkable change was produced in the composition of the several bones by the difference of diet; or, in other words, that the composition of the bones is independent of the nature of the food. The bones were, however, stunted in their growth.

From the researches of Schöne on the conduct of ozone and water toward each other, it appears that ozone does not oxidize water; that ozone is absorbed by water in considerable quantity, even at the ordinary temperature; that when ozonized oxygen is conducted through water, the amount of ozone contained in the mixture is diminished; and that ozone in contact with water is slowly changed to ordinary oxygen.

A patent has been granted for an India-rubber shoe, or rather *overshoe*, for horses, as it is called by the *Scientific American*. The shoe is made and lined precisely in the same way as the "arctic overshoe," and in fact presents no difference, save in its shape and in its manufacture, from the best quality of India-rubber. Horses suffering from cracked or contracted hoof are soon cured by the use of these elastic shoes. The cost of rubber shoes, as compared with those of iron, is about one-third more, and their weight is about 40 per cent. less.

A correspondent of the Department of Agriculture, writing from Stanley County, North Carolina, notes a curious fact observed in growing turnips on land previously sown with the opium-poppy: the turnips came up, but never got beyond the seed-leaf. Repeated sowings on the same lot had the same result. On the other hand, turnips sowed in spots not far removed from the poppies, did very well, and were less annoyed by insect enemies than ever before. "Can it be," asks the correspondent, "that the opium-poppy leaves in the ground elements incompatible with the life of the turnip?"

At the instance of the German Anthropological Society, statistical information is to be collected from schools and military depots throughout the German Empire, with a view to the solution of the vexed question, whether there are two distinct types of Germans, one tall and fair, the other short and dark.

Dr. Joseph Fraunhofer.

THE

POPULAR SCIENCE MONTHLY.

APRIL, 1875.

THE TRIANGLE SPIDER.

By Prof. BURT G. WILDER,

OF THE CORNELL UNIVERSITY.

STROLLING through the woods near Ithaca, New York, one October afternoon, I saw, upon a leafless hemlock-branch, what looked like a piece of the net of some geometrical spider. Still, there was a regularity in this triangular net which did not accord with the idea of its being a fragment. A closer examination showed that its form and structure were perfect and unbroken; and moreover that, instead of hanging loosely from the twigs, it was *upon the stretch*, as if constantly drawn by a power at one or the other end (Fig. 1).

On touching the net to determine its degree of tension, what was my amazement to see it suddenly loosened with a snap, as if let go at one end! Nor was my wonder diminished when, a moment afterward, the the net slowly regained its original condition, by a steady pulling upon a short line connected with the apex. And now I saw the puller—a little dull-colored spider, about one-eighth of an inch long—hanging from the under side of the apex-line, and hauling it in, not "hand over hand," as at first appeared, and as one would suppose by analogy with sailors' operations, but "foot over foot;" in short, with its *hinder legs* moved alternately so as to gradually take in that part of the line which intervened between its body and the twig to which it was attached.

When this line was all taken in, the spider was close against the twig, and its legs were drawn together, so that the whole formed a compact brown mass about the size and shape of a raisin-seed, and differing so little in appearance from the projections of the dried hemlock-twigs among which the net was built, that I felt in part excused for not having noticed the little creature before.

So much for an introduction to a spider which was then new to me, and probably is still unknown to most of my readers. In some respects its habits are unlike those of all our other spiders; and I will here relate what I have learned during five seasons, in the hope that others may have the fortune to clear up the points in its economy as yet undiscovered.

Our spider is thought by high authorities to be a species of the genus called *Hyptiotes* by Walcknaer, and afterward and more commonly *Mithras;* but the former name has priority. Of this genus two European species have been described; one of which, *H. paradoxus*, has lately been found in England, and described by the veteran arachnologist, Mr. Blackwall. Our American species seems to be that referred to by Hentz as the *Cyllopodia cavata*,[1] but his description is so brief,

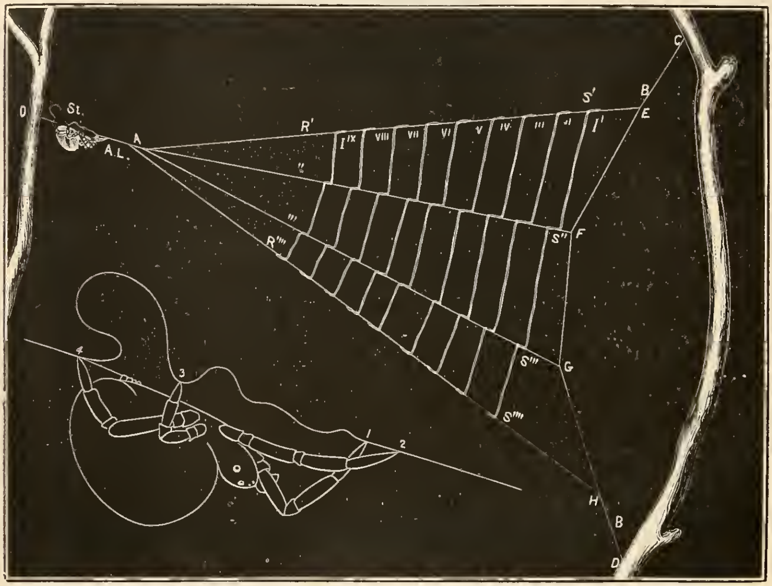


Fig. 1.—Net of the "Triangle Spider." about one-half the usual length. The spider, however, is shown of the natural size.

B B, the base-line attached, at *C* and *D*, to a hemlock-branch; *E F G*, points of attachment to the base-line of the three radii, *R'* to *R''''*, which converge at *A*, the apex of the net; I' to I^IX, nine transverse or interradial double lines; *S'* to *S''''*, attachments of the first interradial upon the radii; *A L*, apex-line; *O*, origin of the apex-line from a second branch; *Sl.*, loop of the apex-line or "slack," between the front and hinder feet of the spider: this is better shown in the lower enlarged figure.

and in some respects erroneous (giving only six eyes, whereas there are eight), that we shall probably avoid confusion by calling this a new species (*H. Americanus*).

Having now identified the spider sufficiently for our present purpose, we have to inquire:

1. Which is *the spider*, the male or the female?
2. How is the net made?
3. How is the net used in taking prey?
4. What are the relations between this and other spiders?

1. Which is the Spider? As is often, although by no means

[1] *Boston Journal of Natural History*, 1847, vol. v., p. 466, plate xxx., Fig. 3.

universally, the case among spiders, the female is the head of the family. In fact, so scarce are the males that for three years I never found one among more than a hundred specimens. This, however, is not absolute proof of their much smaller number, for they are less in size and darker in color, and, like the males of the "silk-spider of

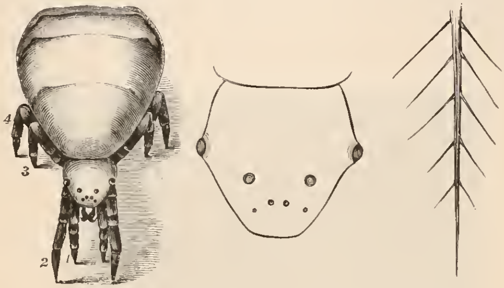


FIG. 2.—At the left a female *Hyptiotes*, enlarged about eight diameters. The legs are marked 1, 2, 3, 4. in order from before backward. In the central figure is shown the front part of the spider (the cephalo-thorax), still more enlarged, so as to display the eight eyes arranged so as to form two crescents with their convexities opposed thus ≍. At the right is a greatly-magnified feathered bristle from the upper surface of the cephalo-thorax.

South Carolina" (*Nephila plumipes*), they make no nets, but seem to get a precarious living by hanging on to that of some female. Their masculine nature is seen in the structure of the "palp" or feeler, which, instead of tapering to a blunt point, as in the female, is greatly enlarged, its last segment presenting the remarkably complex structure seen in Fig. 3.[1]

FIG. 3.—Terminal joints of the palp or feeler of the male *Hyptiotes Americanus*, much enlarged. (Drawn from Nature, by Prof. W. S. Barnard.)

[1] These modified palpi are undoubtedly connected with the reproductive function. Others besides myself have seen them (with other and larger species) applied to the vulva of the female during an evident copulation; but all do not assent to the generally-received opinion, that they are merely intromittent organs, which have first received the spermatic fluid from the testicular orifice upon the ventral surface of the abdomen. (For a note upon the subject, by Mr. Gedge, with references, *see Journal of Anatomy and Physiology*, 1867, vol. i., p. 371.)

It is possible that, as with the *Nephila plumipes*, the *young* males of *Hyptiotes* construct nets, but of this I can say nothing; for as yet I have never seen what I was certain were the eggs or the very young. Near Ithaca I have found the partly-grown spiders, during the latter part of July, and the adults are all gone before the close of November. Certain little cocoons (Fig. 4), which are quite abundant in the same localities and upon the hemlock-twigs, may prove to be made by this spider, but at present all is conjecture.

Fig. 4.—Supposed Cocoon (Egg-Case) of Triangle Spider.
A, the cocoon, of natural size, hung by thread-lines between hemlock-twigs; *B*, the cocoon enlarged, seen obliquely, so as to show the triangular base.

The form of these cocoons is quite peculiar: it is that of a little sphere flattened upon one side; at three points the border of this flat side is extended into strong lines, by which the cocoon is suspended between the twigs. Its diameter is about one-tenth of an inch, but the lines are often two or three inches long. The ground-color is usually white; but there are always a few black specks, and sometimes these cover so large a portion of the surface as to make the cocoon appear gray or nearly black.

Besides these more common cocoons, the hemlock-twigs sometimes bear others of about the same size, but pear-shaped, and hanging by the smaller end upon a single short line. To identify these, the spiders should be taken in September, and kept in captivity upon hemlock-branches, so that they may make their cocoons.

2. How is the Net made?—Like most geometrical spiders (*Epeiridæ*), the *Hyptiotes* prefers to construct her net just before day. She is then less liable to interruption, and the newly-made net is best adapted for use in taking the builder's breakfast. To these early habits on the part of the spider is owing the fact that, although I have kept many of them in the house, I have never yet been so fortunate as to witness the entire process of net-making. Twice I sat up all night, but the spiders must have begun just as I fell asleep shortly before day; and my readers will understand that, in the midst of the fall term, a professor does not often feel able to spend a night in watching spiders.

However, I have twice witnessed the completion of nets, and have seen enough of the process to enable me, aided by what is known of spiders' methods in general, to infer how the net is begun and carried on, and the correctness of the following description may be accepted as at least probable, until disproved by actual observation of the entire process:

Fig. 5.—*a*, last two segments of the hinder (fourth) leg of a female *Hyptiotes*; *b*, tip of the last segment, showing the claws open; *c*, cross-section of the last segment but one, showing its cavity, in which lie the muscles, and a single curved bristle upon the side, a part of the *calamistrum*; *e*, a similar bristle still more enlarged; *d*, *f*, two feathered bristles from near the joints.

Having first decided upon the general location of her net, the spider probably takes position head downward upon the "leeward" side of a twig or small branch, or upon its top, and then, turning her abdomen outward, expresses from her spinners a drop of gum, which instantly dries so as to form a fine end of a silken thread. This is taken by the wind (and careful experiments have proved that a current of air is absolutely necessary to the extension of the line) and wafted outward, waving from side to side, and usually tending upward from its extreme lightness, until at last it touches some other branch at a greater or less distance from the first. When this stoppage is perceived by the spider, she turns about and pulls in the slack line, until she is sure that the other end is fast. If it yields, she tries again and again, until successful. If it holds, she attaches her end firmly by pressing her spinners upon the wood, so as to include the line. The first and most important step in the construction of all geometrical nets has now been taken, and the spider can meet with no serious difficulty in completing her task.

But the following steps might be taken in more than one way, and perhaps are so at different times, or by different individuals. And, in view of the risk of making inferences as to the habits of animals, I refrain from the description of what may occur, and simply state that in some way the spider connects with the original horizontal line four others, constituting respectively the base-line ($B\ B$) of the net, and the three lower radii ($R''\ R'''\ R''''$) which are joined to the base-line at F, G, and H. The upper radius (R') is formed from the central part of the original line, and the three others unite with it at A, the apex of the triangular net. (*See* Figs. 1, 8, 9.)

The framework of the net is now ready, and the spider begins to construct the more essential part of its snare.

The organs directly concerned in the operation are the hinder pair of legs and the spinning mammulæ, or spinnerets.

The fourth pair of legs have, upon the last segment but one, a series of strong and curved spines, forming a rake with teeth finely set. When used, this rake appears to be carried backward over the spinnerets, so as to draw out the silken threads.

It seems to represent the *calamistrum* of the other *Ciniflonidæ*, but has no such effect, as with them, as to form a flossy border upon the silken thread.

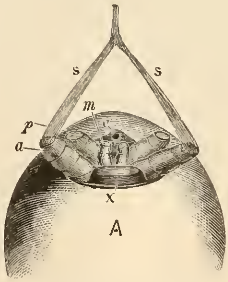


Fig. 6.—View of the Spinning Apparatus of *Hyptiotes Americanus*, from below and in Front.

A, the lower surface of the abdomen; v, the vent or outlet of the intestine, opening through a papilla; a, one of the anterior pair; p, one of the posterior pair; m, of the middle and smaller pair; x, a low oval projection just in front of the spinners, which seems to correspond to the fourth pair in other species; $s\ s$, the silk from the anterior spinners, uniting to form one line, but capable of drying so as to form the two strands of the double interradial. I do not know from which spinners the various parts of the net are formed.

The *spinning mammulæ*, or *spinnerets*, are represented in Fig. 6. They form a little group upon the lower surface of the abdomen, near its hinder end. In a state of rest, they are closely approximated, but when in use they are more or less widely spread apart like so many fingers or short legs. Indeed, there is reason to regard the spinners as corresponding in essential structure with the true legs of the spider. They are jointed or articulated, and capable of considerable movement. Their number and form vary with different genera. In our spider there are three pair, anterior (a), middle (m), and posterior (p). The middle pair are smaller, and ordinarily concealed by the others. Behind the spinners is the median papilla through which opens the vent (v). In front of them is a low, broad, oval-topped papilla (x), in which I find no trace of division into two, nor any silk-tubes. It probably represents the fourth pair of spinners, which exist in the other *Ciniflonidæ.*

The tips of the spinners are provided with many little tubes, having the appearance seen in Fig. 7. Through these is drawn the gum

Fig. 7.—A Single Silk-Tube from the End of an Anterior Spinner.

secreted by the silk-glands within the abdomen, and all the strands from a single spinner may combine to form a single thread.

It is probable that the different pairs of spinners are supplied from different glands, and that they are employed in making different parts of the net. With the *Nephila plumipes*,[1] I found that from one pair came only white silk, while another pair produced only yellow. By separating these with pins, soon after leaving the body, and attaching

[1] For an account of this species, and of the *Epeira riparia*, see the following papers:

"On the *Nephila plumipes*, or Silk-Spider of South Carolina" ("Proceedings of the American Academy of Arts and Sciences," November, 1865).

"On the *Nephila plumipes*" ("Proceedings of the Boston Society of Natural History," October 4, 1865).

"On the Silk-Spider of South Carolina; Four Lectures before the Lowell Institute, March, 1866" (unpublished).

"How my New Acquaintances spin" (*Atlantic Monthly*, August, 1866).

"Memoirs of a Cripple" (*Our Young Folks*, September, 1866).

"Researches and Experiments upon Silk from Spiders" (Termeyer, 1810–1820?) edited by B. G. W., and published in the "Proceedings of the Essex Institute," Salem, Mass., July 6, 1874.

"Two Hundred Thousand Spiders" (*Harper's Magazine*, March, 1867).

"The Practical View of Spider's Silk" (*The Galaxy*, July, 1869).

"The Habits and Parasites of *Epeira riparia*" ("Proceedings of the American Association for the Advancement of Science," 1873).

'The Nets of *Epeira*, *Nephila*, and *Hyptiotes* (*Mithras*)." (Ibid.)

them to a cylinder, the two colors were wound separately from the living spider. Thus far, however, I have failed to ascertain their distinction with this species. So my figure and description may not be correct in assigning to the anterior pair the duty of supplying the interradial lines.[1] However, it seems probable that the process is as follows: One or more pairs of the spinners are first pressed together and then separated. This draws out the silk as a band connecting their tips. By keeping them apart, and repeatedly carrying the *calamistrum* backward across their tips, the lines from each of the two mammulæ in one pair are kept separate until thoroughly dried. When the line is completed and drawn taut they remain distinct, but very near together.

We are now ready to observe the way in which the spider employs the organs above described. Let us suppose that the framework of the net is completed, and that the first or longest interradial line (Fig. 8, I') has also been made. Instead of beginning the second interradial at S'''', she begins at 4; and instead of climbing up the interradial or the strong and convenient base-line (B B), she runs to a point (2) near the apex, crosses the two intermediate radii, and passes along the upper radius to the attachment of the first interradial (S'). On reaching this, she turns and moves for about her own length toward the apex. Contrary to the usual habit of spiders, during this roundabout passage from 1 to 4 she spins no thread. She now spreads her spinners a little, and presses them upon the radius, keeping them so while she advances again about her own length. This forms the attachment of the second interradial. The spider then lets her abdomen fall somewhat, supporting her body and advancing upon the line by means of her first, second, and third pairs of legs. The fourth pair are applied together to the spinners with great rapidity, at least five times in a second or three hundred times in a minute, and in so doing they draw out a *double line*.[2]

The spider moves slowly along the radius until she reaches a point (5) where she can step across to the next radius (R''). While so doing, she ceases to draw out the double line, and carefully keeps it from

[1] From a notice in the *American Naturalist* for February, 1875 (page 125), it appears that Mr. A. J. M. Underhill has lately published, in *Science Gossip*, some observations upon the employment of the different pairs of spinners. He assigns to the third (middle?) pair the production of a line which is either viscid or curled.

[2] I must here admit an error in a previously-published account of the net ("Proceedings of the American Association for the Advancement of Science," 1873, pages 264–274). The interradial lines were there described as *viscid*. The fact is, that I had never thought it necessary to examine them under the microscope, since the interradial lines of all the *Epeiridæ* are viscid; that is, consist of a slender axis enveloped by a viscid coating, which, soon after the net is completed, runs spontaneously into minute globules. Finding that the interradial lines of the "triangle-spider" were elastic, and that they readily adhered to the prey, or to any other body, I not unnaturally, but most unscientifically, drew the inference that with this spider the lines were likewise viscid. During the summer of 1874, while examining the manner of attachment of these lines to the radii, I saw that the interradial lines were neither viscid, like those of the *Epeiridæ*, nor provided

contact with either of the radii. She then retraces her steps along the second radius to a point (6) nearly under that whence she started. The double line has shortened itself considerably; any slack she draws in, and then, turning about, with her head toward the apex, she makes a second attachment with her spinners close pressed against the radius.

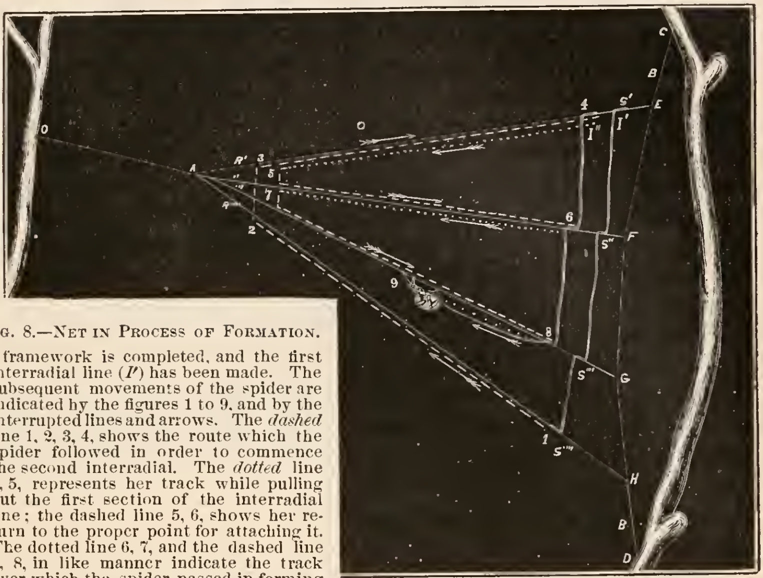


Fig. 8.—Net in Process of Formation.

The framework is completed, and the first interradial line (I') has been made. The subsequent movements of the spider are indicated by the figures 1 to 9, and by the interrupted lines and arrows. The *dashed* line 1, 2, 3, 4, shows the route which the spider followed in order to commence the second interradial. The *dotted* line 4, 5, represents her track while pulling out the first section of the interradial line; the dashed line 5, 6, shows her return to the proper point for attaching it. The dotted line 6, 7, and the dashed line 7, 8, in like manner indicate the track over which the spider passed in forming the second section of the second interradial. The dotted line 8, 9, shows the progress of the spider toward making the third section. The net is considerably reduced, but the spider is of about her usual size.

This done, she again hangs from the radius, draws out the viscid line, and advances toward the apex, crosses at 7 to the third radius (R'''), retraces her steps thereon to 8, and makes a third attachment. She then repeats the same process upon the third radius, and, in Fig. 8, is represented as having finished about one-half of the line.

It must be borne in mind that the spider is not reduced, like the net; and also that, to save space, the interradial spaces are not so wide

with a fine floss, as with the other *Ciniflonidæ*, but simply *double lines*, the two strands being from $\frac{1}{500}$ to $\frac{1}{2000}$ of an inch apart.

My error exemplifies the utter insufficiency of property and function as a guide to structure, and enforces the general principle in natural history, that nothing should be stated as a *fact* that has not been verified by *observation*. It was his avoidance of this kind of error which rendered the work of the late Prof. Jeffries Wyman so remarkably trustworthy.

Since the foregoing was in type, I have learned from Mr. J. H. Emerton, of Salem, that some of his observations upon the structure and economy of this spider do not accord with those here recorded. It is to be hoped that the views of this accomplished and enthusiastic arachnologist will be incorporated with the new edition of Hentz's papers, which he is preparing for publication by the Boston Society of Natural History.

as in Nature. The remaining interradials are formed in like manner, their number varying from six to fifteen.

It will be seen that, by first making the double line nearest the base-line, and afterward the others in their order, the spider avails herself of the fact that a less and less distance is to be successively gone over before crossing from one radius to the next; whereas, if she made the shortest double line first, then she would either be liable to entangle the other if she crossed at the apex, or, if she went around by the base-line, the distances to be gone over would constantly decrease *inversely* to the lengths of the double lines themselves, causing either waste or entanglement.

It is not yet certain just how long a time is required for making the entire net; but, in one case, the spinning of the five lesser viscid lines occupied the spider ten minutes; the other and longer ones may have taken twice as long; and, as the return-movements are rapidly executed, we may say that, for at least half an hour, the little spider is moving her hinder legs together and with great precision at the rate of 300 times per minute, making the total number of movements 9,000!

How is the Net used?—If the making of the net is peculiar, its use is even more remarkable; and here, fortunately, few points remain to be cleared up; for the spider's response to a disturbance of her net by a fly is so prompt that one may, at any time, witness the operation.

At the close of what to the observer seems a pretty energetic exercise of all her faculties and powers, the spider, without a moment's rest, goes to a point upon the apex-line about an inch from the origin (*O*), and, firmly grasping the line between the first and second pairs of feet, she walks backward, foot over foot, until her hinder feet are caught in the attachment itself, or in the thickened line near it; in so doing, a certain amount of slack-line has been furled up between the two points held by her hinder legs and the front ones; this slack is kept away from her body by means of the third pair, which are shorter than the others. Evidently the effect of the above operation is to draw the net toward the apex, the two middle radii being most affected, and with them the central portion of the base-line to which they are attached; and the whole net assumes the appearance shown in Fig. 1.

It is now upon the stretch; and the degree of tension is very considerable, judging from the violence of the snap when it is let go; the exact amount has not yet been measured, but, when it is borne in mind that the spider remains motionless for hours, perhaps for days, constantly holding her net ready for action, we may conclude that, as is the case with other insects, her powers and her endurance are, in proportion to her size, quite beyond what we are familiar with among the higher animals. But our spider's ability to keep still is fully equaled by her capacity for action when the moment arrives; and yet she is by no means hasty; as a general thing (the exceptions being due perhaps to hunger, or inexperience), the vibration of the net by an insect must be pretty decided, and at least once repeated, before the spider feels justified in springing her trap; and when, as may sometimes happen naturally, but more often through experiment, a large or fierce insect is put into the net, nothing will induce the spider to budge; she will suffer her net to be wholly destroyed rather than expose herself or her reputation (?) to a doubtful encounter. Let us suppose, however, that a common fly, or a gnat, or a moth, has

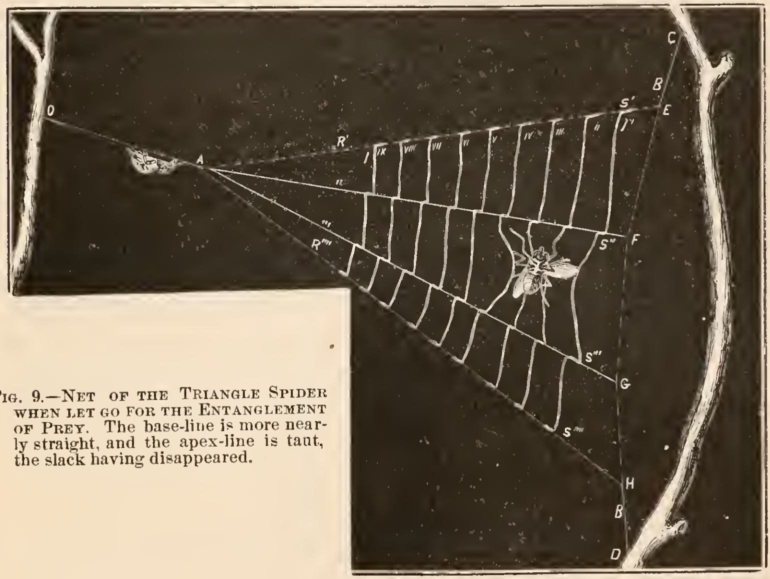


Fig. 9.—Net of the Triangle Spider when let go for the Entanglement of Prey. The base-line is more nearly straight, and the apex-line is taut, the slack having disappeared.

struck the net in passing—it may have touched a single double line—but this adheres with the greatest tenacity, and is so elastic as to yield without breaking, so that each struggle involves the victim still more, and may even bring it into contact with the next interradial. As soon as the violence and repetition of the vibration indicate that an insect is really entangled, the spider awakes from her apparent apathy; she lets go with her hinder feet; the net, released from its tension, flies forward, and at the same time flaps from side to side.

The comparative inertia of the fly causes the two or three double lines next to it on the side toward the apex to be, as it were, propelled against it, and the entanglement is aided by the sidewise flapping already mentioned; as may be imagined, all this is pretty apt to involve the fly beyond the possibility of escape; but, if the spider does not feel certain of this, she creeps backward again, foot over foot, as before, and again springs her net; and this I have seen repeated in quick succession *six times* before the spider has ventured to make a personal approach. She has already been carried a little way toward her prey by the snapping of the net, for she always retains her hold of the apex-line by her first two pairs of feet, and the third pair serves to steady her as the slack-line slips between them. Advancing now to the junction, she seems to ascertain the exact location of the fly by pulling upon the radii.[1] Having decided, she runs along the chosen radius, and sometimes, when the prey is small, or hopelessly entangled, contents herself with pulling it up by means of the lines about it, and carries it to her accustomed station to be eaten at her leisure.

But more often she adopts a method of securing her prey which, so far as I know, is peculiar to this genus, and involves the destruction of her entire net.

Before reaching the apex (*A*), she cuts with her jaws the apex-line, but, as she keeps constant hold in front of the cut by her first and second pairs of feet, and has a communication in the rear through the line which most spiders always attach to a point behind them, she does not fall, neither is the net loosened beyond a certain limit; it usually seems to recoil about an inch; this recoil tends to entangle the prey like the original snaps of the net. The spider again advances, gathers the radii together and cuts them all, still keeping the line out behind; again the net recoils and collapses. Again she advances and cuts the radii; the net is now hardly distinguishable as such, and is falling together about the devoted fly; the spider now spreads her legs, gathers the net between them and flings it like a blanket over her victim; struggles are now in vain; but, "to make assurance doubly sure," the spider grasps the mass, transfers it to her third pair, and with them turns it over and over as a ball, hanging the while by her front legs, and, with the hinder pair used now *alternately*, drawing out from the expanded spinners broad sheets of silk which, relatively to the power of the fly, are like steel bands upon a man. Having in this way reduced the prey to a rounded ball, in which its limbs are hardly distinguishable, the spider takes it in her jaws and mounts to her place.

A single fly of ordinary size seems to occupy a whole day in the eating. When finished, the remains are cast down as a pellet, so perfectly deprived of moisture, that it is probable that this species, like the *Nephila*, and perhaps all *Epeiridæ*, sucks out the gum of its old net and reëlaborates it in her organs for use in making a new one.

Whether this peculiar economy is practised or not, it is certain that the *Hyptiotes* often sacrifices its whole net in the capture of a single fly; and that the making of this net involves an amount of labor and of skill which one would think not lightly to be thrown away.

[1] As with the *Nephila*, and perhaps all other geometrical spiders, this species seems to perceive *light* only, and not to see objects distinctly.

THE RELATIONS OF HYPTIOTES.—In these days of evolution, we can hardly wait to learn what an animal does in the present, before we inquire what its ancestors were, and how it came to be what it is.

Ideally, one may at once draw a curious comparison between *Hyptiotes* and two other spiders already referred to in this article, namely, the *Epeira* and the *Nephila*; for the net of the former is a complete circle, that of the latter is a circle lacking its upper sextant, while the net of *Hyptiotes* is just about the sextant or sixth of a circle. To use a more homely comparison, the net of *Epeira* is an entire pie, that of *Nephila* is a pie with a piece cut out, while that of *Hyptiotes* represents the missing piece. In algebraic language, *Nephila* + *Hyptiotes* = *Epeira*.

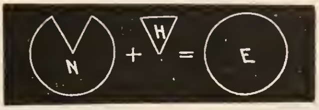


FIG. 10.—DIAGRAM REPRESENTING THE FORMS OF NETS OF NEPHILA (N), HYPTIOTES (H), AND EPEIRA (E).

But, while the above comparison enables us to contrast the nets of the three genera, it by no means satisfies the inquirer as to the derivation of the forms in question. To answer this in full would require a more complete knowledge than we now possess, and would involve a discussion too technical for these pages; but there are a few considerations easily presented, which indicate that the gaps between the forms are not so great as at first appears.

1. The net of the ordinary geometrical spiders, like that of *Epeira riparia*, consists of a continuous spiral viscid line laid upon radii, while that of *Nephila* presents a larger number of radii upon which is laid a *looped* viscid line, which does not extend across that part of the circle just above the centre. But in several nets, otherwise of usual geometrical character, I have found one or the other side, but usually the bottom, extended considerably by the addition of several *looped* lines, like those made by *Nephila*; so that we may imagine that *Nephila* has merely perpetuated and intensified into constancy a method of net-making which was occasionally employed by the form from which it and the common *Epeira* are both descended.

2. At least one species of *Epeira* (the *E. calophylla* of Great Britain, described by Mr. Blackwall) constructs a net of looped lines, like that of *Nephila*, but the loops terminate on both sides of a *single* radius, which serves as a line of communication between the centre of the net and a cell under a neighboring leaf. Now, if we imagine the net to be reduced from many radii to four, then the single divergent radius of *E. calophylla* would represent the apex-line of *Hyptiotes*

3. Many and perhaps all geometrical spiders are accustomed to shake their nets violently when touched, and sometimes to seize

several radii in their claws, and draw them up and let them go suddenly; such a habit may have been the foundation of the remarkable device adopted by *Hyptiotes.*

One further inquiry is suggested by the fact that the net consists invariably of *four radii.* Whatever other variations there may be in the spider's work, as to the size and proportions of the net, and the number of interradial lines, the *number of radii is constant.* In more than a hundred nets, I have found the number to be *four*, never more nor less. Now, this seems to offer a confirmation of the common idea that spiders' webs, like bees' cells, are constructed with absolute accuracy, and are models for poor humanity.

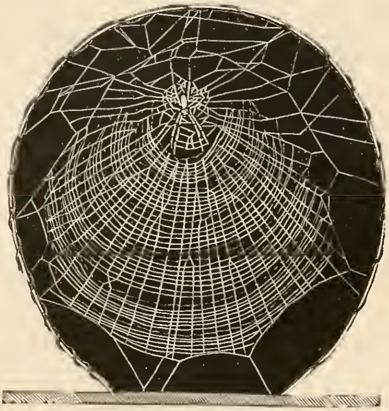


FIG. 11.—NET OF *Nephila plumipes*, made in a wire frame, and photographed upon wood; reduced. In nature, the free radii, as above described, occupy about ⅛ of the area; but the web of which a figure is given was made upon a frame, the limits of which seem to have interfered with the extension of the loops above the level of the centre of radiation.

But Prof. Jeffries Wyman has shown that *no such exactitude prevails with the cell of the honey-bee;* for, while the average diameter of a large number of worker cells is about one-fifth of an inch, yet the difference between two cells has been found to be one-fortieth of an inch, and the aggregate diameter of ten cells may differ from that of another set of ten cells one-fifth of an inch, or the diameter of a single cell. The width of the sides varies to an appreciable extent; likewise the angles between the sides; a fourth face is often introduced into the base, and the rows of cells may be greatly out of line; in short, while it is probable that the bees work with reference to an ideal or type implanted in them, Prof. Wyman is inclined to *doubt whether a type-cell is ever really made.*[1]

The reader will now be prepared to hear that, after careful examination of large numbers of nets of many different spiders, I have yet to find one in which the irregularities could not be detected by the

[1] "On the Cells of the Honey-bee" ("Proceedings of the American Academy of Arts and Sciences," January 9, 1866, pp. 68–82; 6 figures).

eye. The radii and viscid lines differ in number (the number of radii being constant only in *Hyptiotes*). Their distance apart varies greatly, as might be expected from the fact that spiders make their measurements hastily, and with no apparent attempt at precision; in fact, the irregularities are such as would disgrace any human artificer. We must conclude that the popular belief upon the subject is based upon very superficial observation, and that it had its rise in the old theological idea that because the Creator is perfect, so must be the performances of all his creatures, excepting the one example of total depravity—man.

But let this not trouble us. Like the orthodox interpretation of Scripture, so the orthodox interpretation of Nature may be far out of the way; and the readiness with which the world has accepted new views, when their correctness is beyond controversy, and yet kept its faith in the power, the wisdom, and the goodness of God, shows the truth of the following aphorism: "It is important not to confound the fundamental order of Nature, which is indeed immutable, with the ideas, more or less complete, which we entertain at a given time, respecting the manner in which that order is manifested."

THE ROYAL INSTITUTION AND THE SOCIETY OF ARTS.[1]

By BERNARD H. BECKER, Esq.

COMMENCING with the nineteenth century, the Royal Institution, that stronghold of fashionable science in Albemarle Street, can claim for itself many of the most remarkable discoveries which have distinguished an era of unrivaled activity. It owes its origin partly to Sir Joseph Banks, but in a far greater degree to a more remarkable man. Benjamin Thompson, afterward Count Rumford, was a lineal descendant of one James Thompson, who figured at Charlestown in Winthrop's company in 1630. Born in his grandfather's farmhouse, he enjoyed the advantage of a good grammar-school education, and then advanced in the world by the steps familiar to this day in America, but almost unknown in Europe. He was apprenticed to an importer of British goods, was allowed to make small ventures on his own account, fancied that he had invented perpetual motion, took a great interest in questions relating to light, heat, and the wind, lost his place, and blew himself up with fireworks before the age of sixteen. At seventeen he was a dry-goods clerk in Boston, studied French during his evenings, and got himself an electrical machine with money earned by cutting and carting firewood. He then boarded for some eighteen months with a Dr. John Hay, and picked up a little anatomy, chemistry, surgery, and physic, and in 1771 went to Cam-

[1] Abridged from "Scientific London."

bridge, Massachusetts, to attend Winthrop's lectures on "Experimental Philosophy." He then, after the manner of his country, "taught school" at Wilmington; and afterward became master of a school at a place originally called Rumford, but subsequently rechristened Concord, when the disputes as to the State to which it belonged were finally settled, and it was ceded to New Hampshire for good and all.

Shortly before attaining the age of twenty, Thompson, a fine, handsome young man, married—or, to use his own expression—"was married by" Mrs. Rolfe, a wealthy widow of Concord. There was now no more occasion to "teach school," and Thompson hoped for leisure to pursue science vigorously; but the American Revolution breaking out, he speedily found his way to England, in 1778 was elected a Fellow of the Royal Society, and two years later became an under-secretary of State, and colonel of the king's American Dragoons. At the conclusion of the war he was knighted by George III., and, having met the Elector of Bavaria at Strasbourg, passed a considerable time in Munich, busying himself in improving the breed of cattle and in building workhouses, and it was in order to find the most economical method of lighting the workhouse in Munich that he initiated the series of experiments afterward embodied in a paper on "The Relative Intensities of the Light emitted by Luminous Bodies," read before the Royal Society.

Honors now fell thickly upon the successful American. In 1785 he was elected member of the Bavarian Academy of Sciences, and in the two succeeding years was made a member of the Berlin Academy of Sciences, and received the order of St. Stanislaus. Finally, Sir Benjamin Thompson became Lieutenant-General of the Bavarian Armies, received the order of the White Eagle, and was made a Count of the Holy Roman Empire.

After the death of his wife he traveled for sixteen months in Italy, and during his stay at Verona rebuilt the kitchens of the two great hospitals—La Pieta and La Misericordia. Seven-eighths of the firewood were saved, and his success in this enterprise appears to have greatly encouraged Count Rumford to pursue his investigations into the proper management of fuel. A curious essay written by him about this time contains the mixed philanthropic and philosophic germ of the Royal Institution. This is a "proposal for forming in London, by private subscription, an establishment for feeding the poor and giving them useful employment, and also for furnishing food at a cheap rate to others who may stand in need of such assistance, connected with an institution for introducing and bringing forward into general use new inventions and improvements, particularly such as relate to the management of heat and the saving of fuel, and to various other mechanical contrivances by which domestic comfort and economy may be promoted." This was followed by other essays on "Food and feeding the Poor," on "Rumford Soup and Soup-Kitchens," and on "Chimney Fireplaces." The Rumford medal was now presented to the Royal Society "for discoveries tending to improve the theories of fire, of heat, of light, and of colors, and to new inventions and contrivances by which the generation, and preservation, and management of heat and of light may be preserved." The endowment of the medal consisted of £1,000 stock, and was, I may add, presented on the first award, in 1802, to its founder. Meanwhile Rumford went to Ireland and fitted up laundries and model kitchens, cottage fireplaces, and model lime-kilns; served in Bavaria, preserving by his firmness and skill the neutrality of that country; and finally determined to return to America, but was deterred from carrying out this project by his anxiety to launch the Royal Institution. In the mind of Rumford the dominant idea was originally that of bettering the condition and increasing the comforts of the poor. A society was formed for this purpose, and out of it sprang, from a proposal of Count Rumford, a scheme for forming a new "Establishment in London for diffusing the Knowledge of Useful Mechanical Improvements." The two great objects of the institution were declared to be, the diffusion of the knowledge aforesaid and the teaching of the application of scientific discoveries to the improvement of arts and manufactures in this country. To fulfill the first object were to be exhibited full-sized working models of fireplaces, kitchens, stoves, grates, boilers, coppers, etc., and smaller models of houses, bridges, spinning-wheels, and of all "such other machinery and useful instruments as the managers of the institution shall deem worthy of the public notice."

In order to carry into effect the second object of this institution—namely, "teaching the application of science to the useful purposes of life"—a lecture-room was to be fitted up "for philosophical lectures and experiments, and a complete laboratory and philosophical apparatus, with the necessary instruments, will be provided for making chemical and other philosophical experiments." On the 7th of March, 1779, a meeting was held at the house of Sir Joseph Banks, at which the list of original fifty-four proprietors and subscribers of fifty guineas was read. In addition to the names of Rumford and Banks are found on this list those of Angerstein, Joseph Grote, the Duke of Devonshire, Earl Spencer, Earl Holland, Lord Palmerston, the Earl of Winchelsea, and William Wilberforce. By the end of June, 1801, the Royal Institution had received upward of £20,000 in subscriptions. The site of four houses had been purchased in Albemarle Street, professors of chemistry, physics, and mechanics, had been engaged, daily lectures were delivered, a spacious chemical laboratory had been erected, workshops for making models had been built, and skilled workmen engaged for making apparatus and models of various kinds. Early in this year Count Rumford wrote to his daughter that the Royal Institution was "not only the fashion but the rage," and mentions incidentally that "we have found a nice, able man for this place as lecturer—Humphry Davy." This "nice, able man" was the eminent philosopher destined to explode a great part of Rumford's scheme, his models, his fireplaces, his kitchens, his experimental cooking, and his experimental dinners. In 1802 Count Rumford forsook England for Bavaria—as it turned out, forever—and, like many other benefactors of his species, was considered a good riddance. So far as can be ascertained, the American-Bavarian Count was offensively dictatorial in his manner, and exasperated those whom he did not succeed in crushing. Having shaken off Dr. Garnett, the first Professor of Chemistry at the Royal Institution, he engaged Davy as an assistant lecturer in chemistry, director of the laboratory, and assistant editor of the journals of the Institution. The future president of the Royal Society was granted a room in the house, coals, candles, and a salary of 100 guineas per annum.

The first interview of Davy with Count Rumford was not very agreeable to the young chemist, then in his twenty-third year. The intensely juvenile air of the candidate, his almost provincial manners, and a slight Cornwall accent, sufficed to reduce the glacial count to a lower temperature than usual. With considerable difficulty Davy obtained permission to give a few lectures on the properties of gases. This, however, was sufficient. At the first lecture the variety and ingenious combination of his ideas, and the fire, vivacity, clearness, and novelty, with which they were expounded, enchanted the few who came to listen to the young lecturer, in whom they found united the power of poetry, oratory, and philosophy. The second lecture was crowded, and his course was obliged to be removed to the large amphitheatre, whither his fervid genius, and in some degree his youth and good looks, drew immense audiences. The ladies were charmed by the handsome young lecturer, and never tired of praising the beauty of his eyes, which they declared were "made for something besides poring over crucibles."

Before coming to the Royal Institution, Davy had already attained a certain celebrity by discovering the anæsthetic properties of nitrous oxide, and the period of his professorship was signalized by many brilliant discoveries. Named titular Professor of Chemistry in 1802, he only resigned the chair in 1813. He delivered his last lecture on the 9th of April, 1812, the day after he was knighted by the prince regent, and the day before his marriage with Mrs. Apreece, a wedding which put him in possession of a large fortune. The splendor shed upon the Royal Institution by the new Professor of Chemistry prevented the exhibition of any regret at the entire alteration of the original plan of the establishment. The Institution was no longer a popular school of technical science, but became almost the exclusive property of the higher classes. Ladies of the highest rank, and young noblemen, assiduously followed the lectures of Davy, while his researches in the laboratory produced the most solid results. It was there that he discovered the laws of electro-chemical decomposition, and succeeded in decomposing fixed alkalies—that he established the true nature of chlorine and the philosophy of flame. The electric battery with which the separation of potassium and sodium was operated is still preserved in the Royal Institution along with other apparatus used by Davy. The delight of the investigator, on seeing the globules of the new metal start through the crust of potash and catch fire on contact with the air, was intense. "He could not contain his joy, and danced round the room in an ecstatic transport; it was only after a while that he recovered sufficient calmness to continue the experiment." An immense electric battery was now constructed, and this heavy artillery directed against resisting earths. The result of experiment was to add four new metals to the list—barium, strontium, calcium, and magnesium. On resigning the chair of chemistry, Davy declared that he only renounced teaching in order to devote himself to original investigation, but after this date his life was only marked by one great discovery—that of the safety-lamp which bears his name.

In the year marked by the rising of that brilliant star, Sir Humphry Davy, the directors of the Royal Institution made another great success by appointing to the chair of natural philosophy a man of transcendent genius, the celebrated Dr. Young. He was one of the few infant prodigies who have made a mark in after-life. At two years of age he could read. At four he could recite by heart numerous English and Latin poems, of which last, by-the-way, he did not then understand a word; but by the age of fourteen he had learned—besides Greek and Latin—French, Italian, Hebrew, Persian, and Arabic. His passion for learning was immense, and his talent for overcoming difficulties astounding. On reaching man's estate he was an accomplished linguist, a brilliant mathematician, a botanist, a skillful musician, a neat turner, and a daring circus-rider. This universal genius did not remain long at the Royal Institution, but yet had time to deliver a notable course of lectures on "Natural Philosophy" before his retirement, when his place was occupied by Dalton. The famous author of the "Atomic Theory" was surprised, like other people, at the youthful appearance of Davy, and writes, characteristically enough: "He is a very agreeable and very intelligent young man, and we have extremely interesting conversations of an evening; his principal defect—as a philosopher—is that he does not smoke."

Although in the foremost rank of scientific men, Dalton was far from achieving great success as a lecturer, being almost utterly devoid of the fluency and power of illustration possessed in such a remarkable degree by Davy and Faraday. A most amusing account was given by Babbage of the incidents attending the presentation of Dalton at court. Firstly, he was a Quaker, and would not wear the sword, which is an indispensable appendage of ordinary court dress.

Secondly, the robe of a doctor of civil law was known to be objectionable on account of its color—scarlet—one forbidden to Quakers. Luckily, it was recollected that Dalton was afflicted with the peculiar color-blindness which bears his name, and that, as the cherries and the leaves of a cherry-tree were to him of the same color, the scarlet gown would present to him no extraordinary appearance. So perfect, indeed, was the color-blindness, that this most modest and simple of men, whose only pleasures were a pipe and a game of bowls, after having received the doctor's gown at Oxford, actually wore it for several days in happy unconsciousness of the effect he produced in the streets. The inventor of the calculating-machine, having offered to present his Quaker friend, was evidently in a state of fussy excitement about the result of the experiment. Poor Dalton was compelled to rehearse thoroughly the ceremony of presentation by the inexorable calculator, who—having found the chances in favor of a *faux-pas* to preponderate—was in a dreadful "taking" on the eventful day. The calculator was completely wrong. The king addressed a few remarks to Dalton, who replied in fitting terms, and the tribulation of Babbage was over.

While the claims of science were amply supplied by the genius of Dalton, Young, and Davy, literature and moral philosophy were intrusted to no ordinary hands. During the years 1804–'6, the town-talk of London was divided between young Roscius, the youthful tragedian, and the lectures on moral philosophy delivered by the Rev. Sydney Smith, who, forty years after, said, "I did not know a word about moral philosophy, but wanted two hundred pounds to furnish my house. My success was prodigious." The "loudest wit I e'er was deafened with" probably exaggerated his ignorance of his subject, as he had passed five years at Edinburgh, and had opportunities of hearing Dugald Stewart and Thomas Brown; but in any case the lectures were a certain success in the hands of the eloquent preacher, who, if himself knowing little about moral philosophy, addressed an audience which knew nothing at all. Of very different calibre were the lectures on poetry delivered by Coleridge. It will be recollected that it was in these famous discourses that the author of "Christabel" promulgated those views which have since spread far and wide, and will probably hold their ground when the ephemeral opponents of Shakespeare, and worshipers of a second-rate poet like Schiller, have for long ages been consigned to oblivion.

On the retirement of Davy, in 1813, William Thomas Brand, a distinguished chemist and Copley medalist, was nominated to the chair, which he so admirably filled for forty years. Meanwhile, a young man whose achievements were destined to invest the Royal Institution with peculiar glory had, in a manner of speaking, received the mantle of Davy. Michael Faraday was born at Newington Butts, of poor parents. His father was a farrier, of whom—to the great sorrow of Prof. Tyndall—his son could never call to mind a single trait of intelligence. The boy was apprenticed to a bookbinder, but in his leisure moments learned "a little chemistry and other parts of philosophy." He had so far advanced as to construct for himself an electrical machine, when his master happened to show this specimen of ingenuity to one of his clients, Mr. Dance, who obtained permission for the apprentice bookbinder to be present at the last four lectures of Davy. The youth listened attentively, and made such notes that he was enabled to write a report of the lectures, which he sent to Davy, with a modest request that he might be employed in the laboratory of the Institution. Davy was struck by the clearness and exactitude of the young bookbinder, and gave him, at the commencement of 1813, the post of laboratory assistant. Toward the end of the year he accompanied Davy abroad, as his assistant and secretary. Returning to London in 1815, he recommenced his duties in the laboratory of the Institution, was appointed director of the laboratory in 1825, and two years later became one of the regular professors of the Institution, where his scientific researches, like those of Davy, were made at the cost of the society alone, without any assistance on the part of the state.

Among the many achievements of Faraday are the demonstration of the condensability of many gases, and his investigations into the reciprocal relations of heat, light, magnetism, and electricity. Not the least noble quality of this remarkable man was his marked preference of a purely scientific career over the acquirement of wealth. With the reputation acquired by the year 1832, he might have made several thousands a year by ordinary professional work, but, considering all the time not actually devoted to experiment or to demonstration as a sacrifice of original investigation, Faraday lived and died poor in the world's goods.

At the present day the Royal Institution maintains its renown—thanks to Prof. Tyndall, who, by his work on "Heat considered as a Mode of Motion," has proved himself no unworthy successor of Davy and Faraday. The late president, Sir Henry Holland, was, on his decease, replaced by the Duke of Northumberland, whose keen interest in scientific inquiry is well known. The important office of Treasurer and Honorary Secretary—on which to a great extent the success of the Institution depends—is now ably filled by Mr. W. Spottiswoode.

The Royal Institution, in addition to the attractions of its lectures, possesses a model-room, a newspaper-room, a reading-room, and a library of 36,000 volumes, presided over by Mr. Benjamin Vincent.

As might be expected in a highly-fashionable institution, membership is not acquired at a cheap rate, but candidates who are proposed by four members are immediately admitted to the privileges of the Institution, and pay on election ten guineas (five guineas as an admission-fee, and five guineas as the first annual payment). This payment secures admission to all lectures delivered in the Institution, to the libraries, and to the weekly evening meetings, with certain other privileges—such as the right of admitting two friends to the Friday evening meetings—a privilege often abused on occasions when a lion of unusual magnitude is about to roar. An inferior kind of member is the annual subscriber, who enjoys most of the privileges above named, with the exception of admission to the weekly meetings, from which sublime gatherings he is excluded. Other persons are suffered to subscribe to the afternoon lectures at the very moderate price of two guineas for all courses of lectures from Christmas to midsummer, but are not allowed to show themselves elsewhere than in the lecture theatre, and never there on a Friday night.

This weekly meeting is a wonderful combination of science and society, of physics and fashion, albeit once in a while a printer or photographer manages to obtain permission to dilate on the excellence of his wares, and to thus advertise himself. Nevertheless, in spite of an occasional drawback of this kind, the Friday evening lectures are of sufficiently high class to please all but a purely scientific audience. It is clear that to gratify the members—who are, after all, mere flesh and blood, and not philosophical abstractions—concessions to popular taste and feeling must occasionally be made. Thus, while all may equally enjoy a lecture on the "Acoustic Transparency and Opacity of the Atmosphere"—a subject which, in its practical relation to fog-signals, is full of general interest—those of a higher and drier turn of mind experience ineffable delight when Prof. Sylvester holds forth on the conversion of circular into parallel motion; while the noble army of simple lion-hunters rush not only to hear, but to see, Sir Samuel Baker. On this particular night I find all the approaches to Albemarle Street blocked by carriages, and on making my way into the Royal Institution find the theatre fully occupied at a quarter-past eight o'clock, or three-quarters of an hour before the time of the lecture. With the exception of a few seats reserved for the two Boards of Managers and Visitors, the hall is crowded to the ceiling, every avenue being already jammed with a dense mass of people, among whom gay opera cloaks and *Angot* caps largely predominate over black coats and showy shirt-fronts. A few young men are visible, but, after standing about for a while, and finding it impossible to approach their far friend, these youths vanish through the crowded door-way and are seen no more, thus leaving the entire field clear to the British matron, who prevails to-night to an extent that would have struck terror into the soul of poor Nathaniel Hawthorne. There is no inconsiderable amount of crowding and pushing in this elegant throng, and I am forcibly reminded of the saying of a certain philosopher—who has seen men and cities, and the customs of them—that "a well-dressed crowd is a rude crowd."

So thoroughly and completely packed is every bench, step, and door-way, that it occurs to me as a piece of singular luck that no formidable philosophic apparatus is necessary for a dissertation on the "Slave-Trade of the White Nile," as the space often occupied by Prof. Tyndall's tubs is packed full of chairs, to the great relief of a number of ladies. Sir Samuel Baker delivers his views on the "Slave-Trade" to an evidently sympathetic audience, easily put into good-humor by being told that England was the first nation to set the world the noble example of liberating her slaves—a statement, by-the-way, not precisely accurate, inasmuch as in 1780 was passed an act for the gradual extinction of slavery in Pennsylvania, an example followed four years later by the States of New Jersey and Connecticut, and in 1793 the French abolished slavery in Hayti, forty years before its abolition in our West India colonies. No doubt, to those who had never heard much about slavery, the remarks on its cruelty and injustice were interesting enough, but I, *infelix*, have had my ears too often pierced by shrill American voices, raised to shrieking pitch on this subject, during "the late trouble." Sir Samuel Baker is an excellent advocate for a new crusade against slavery, and produces ample evidence as to the atmosphere of general rascality evolved by slave-holding and slave-dealing, but his arguments, though true enough, are not very new. The lecturer, however, possesses the excellent gift of carrying his audience along with him, and sends them home happy in the conviction that they have assisted at an anti-slavery demonstration.

The claims of science are amply vindicated on the following Friday by Dr. Wright, an experimentalist of known boldness, who delivers a discourse on the "Chemical Changes accompanying the Smelting of Iron in the Blast-Furnace." Dr. Wright has enjoyed the advantage of pursuing his investigations in concert with Mr. Lowthian Bell, a gentleman well known by his inquiries into the chemistry of the blast-furnace, as well as by his office as President of the Iron and Steel Institute, and his gigantic enterprises in the production of iron and chemicals. Although of little interest to the general public, this lecture commands a good attendance of experts, who follow Dr. Wright very attentively through his exposition, and endure, without a murmur, an atmosphere heavily charged with noxious gases.

I have already observed that, in addition to the Friday evening meetings, where lions of the first magnitude roar by turns, several courses of afternoon lectures, in which actual teaching is combined with attractive experiments, are given during the session. These lecturers and their subjects attract audiences of varying strength. Looking in, one afternoon, to hear a lecture on Paleontology by Prof. Duncan, I find the theatre but thinly attended, in spite of the interesting character of the lecture, and its eloquent treatment by the expositor. This apathy may perhaps be explained by the difficulty of inspiring ordinary human beings with a taste for science, pure and simple; as I well recollect that, when—at the dawn of the Darwinian system—paleontological lectures were unavoidably associated with the controversy initiated by that philosopher, every lecture directly or indirectly bearing on the theory of development commanded a numerous and fashionable audience. Attentive listeners sought, in the discourses of Prof. Owen, for facts and deductions more or less damaging to the bold theory advanced in the now famous "Origin of Species by Natural Selection." But the uproar occasioned by the "Essays and Reviews," and Mr. Frederick Harrison's review of the reviewers in the *Westminster*, has nearly subsided, and the polemical element has faded out of geological discussion. Denuded of its controversial spice, paleontology no longer possesses its whilom attractiveness, and the audience of to-day is apparently composed of those who care for the subject for its own sake alone. Prof. Duncan is discoursing on that friend of my youth, the *ichthyosaurus*, and in a few neat and graphic sentences describes the manners, customs, and peculiar structure of the great fish-lizard, with whale-like body, crocodile head, and monstrous saucer-eyes. The *plesiosaur* with the outline described by the late Prof. Buckland as that of a "turtle with a serpent pulled through it" next engages attention, and is described very graphically as a "'longshore-man" of the diluvial period, a prowler on the edges of the great deep, and a snapper-up of unconsidered trifles. *Plesiosaurus* disposed of, the inevitable *pterodactyle* turns up, the flying lizard of predatory habits, the possible progenitor of birds, and the certain original of the heraldic dragon and griffin. The shape of the head and the gradual adoption by this grewsome creature of a breastbone, give still more coherence to the theory that *pterodactyle* is a lizard which is rapidly making up his mind to become a bird. These particulars, and a dissertation on coral islands, make up the body of an interesting lecture, which fails, however, to warm the audience into enthusiasm. Perhaps people don't care for coral islands, or mayhap, to parody a line of Mr. Bret Harte —"the *pterodactyle*'s played out."

On another raw afternoon, about 3 P.M., I betake myself to Albemarle Street, and become the spectator of a widely-different scene. The theatre is already full of eager visitors and thirsters after science, when elucidated by those brilliant experiments which excite the admiration and envy of Prof. Tyndall's imitators—I had almost written rivals, forgetting that in this country, and in his own particular line of physical demonstration, Dr. John Tyndall, F. R. S., philosopher and cragsman, has no rival. At a three-o'clock lecture many ladies are, of course, present, in all the variety of gorgeous array at present infashion, for, however severe may be the mental attributes of these fair students of physical science, no sternness is ever visible in their outward appearance. Pending the arrival of the Professor of Natural Philosophy, these young ladies are chatting pleasantly among themselves. Are they talking science, I wonder, or discussing the merits of the Leonardo da Vinci hat, or the grace and style communicated by the Norwegian waist-belt, with all sorts of turnip watches and other quaint odds and ends dangling from it? Do they know much about liquids and gases, or have they come to learn? Verily, I know not. The well-known lecture-table is covered with apparatus, and a huge bath-tub occupies a considerable space. Mr. Cottrell, the laboratory assistant, is very busy, till, punctual to the stroke of three, a tall, slender man, of undeniably Scottish aspect, steps to his place behind the lecture-table, and a murmur of applause proclaims the satisfaction of the audience at the arrival of the successor of Faraday. The lecture, interesting in itself, is rendered doubly so by numerous and beautiful experiments, which succeed with infallible certainty. Perhaps the listeners to Prof. Tyndall are accustomed to see his experiments "come off" in this way, but the traveler in search of science often sees experiments—chemical, physical, and others—break down with provoking perversity. No approach to any thing like failure occurs to-day, and the applause is great on the light-carrying power of water being demonstrated by an experiment of singular beauty. The prescribed hour appears unnaturally short when the clock strikes, the lecture is closed by a short sentence, and, amid a mighty rustling of silks, the audience prepares to depart. For a few minutes a talkative crowd blocks up the wide staircase and hall, and a sort of scramble takes place for the carriages of which Albemarle Street is full. Fashion takes its departure, and, having laid in science enough to last for a week, leaves the professor to enjoy himself in his admirably-appointed laboratory.

As I wend my way homeward, I reflect on the large amount of good solid work that has been done in the laboratories of the Royal Institution during the last seventy years, and on the effect produced by the dissemination of scientific knowledge among the upper classes. As a firm believer in the doctrine that all revolutions in taste must take their inception above and gradually percolate through the several strata of society, I keenly sympathize with the efforts of the Royal Institution toward inoculating a love for scientific investigation. Following the example of the sun—which first illumines the mountain-tops, and later in the day penetrates into the deeper valleys—knowledge, striking first on the upper social regions, gradually descends, until all sorts and conditions of men are irradiated by its peaceful light.

Like its younger sister in Albemarle Street, the Society of Arts is a notable instance of that drifting faculty which exercises so great an influence on all human institutions. Launched with widely-differing objects on the stream of events, these societies have in a certain measure displaced each other. The Royal Institution, now devoted to literature, and in a greater degree to pure science, was originally founded to promote those objects which have been fostered by the elder society, which, drifting away from Art in its highest sense, has taken in hand industrial art and applied science. One single comparison will demonstrate my meaning. In the beginning of the century—under the auspices of Count Rumford—the Royal Institution undertook to improve the dwellings of the working classes, to warm and ventilate workhouses, hospitals, and cottages, and to exibit and patronize improvements in the economical consumption of fuel and the teaching of culinary science. In the present year the Society of Arts, founded originally to encourage young artists, has offered premiums for the best kinds of culinary and domestic warming apparatus, and has directly fostered attempts to instruct the people of England in the best methods of preparing food.

The Society of Arts has now existed for a hundred and twenty years, and owes its foundation to Mr. William Shipley, a landscape-painter, who, from a "well-grounded persuasion of the extensive utility of the art of drawing to this nation, erected the Academy in the Strand, opposite to Exeter Change." By the efforts of this gentleman a meeting was held in 1754 at Rawthmell's coffee-house, to consider the propriety of establishing a "Society for the Encouragement of Arts, Manufactures, and Commerce."

It was resolved to bestow premiums on a certain number of boys and girls, and an advertisement was issued accordingly. The industrial element, however, was not lost sight of, as, while a number of drawing prizes were advertised, premiums were offered for the discovery of cobalt in England, the growth of madder, and the manufacture of buff leather. The primary object was the encouragement of art, but the view taken of the "polite arts" was a sufficiently wide one, inasmuch as the premiums offered under this head were ultimately grouped under 196 classes. Many prizes were awarded for drawing, and among the recipients was Richard Cosway, who afterward became a Royal Academician, and a portrait-painter of repute. It was soon found necessary to confine the objects of study to certain models, and, as no public museum or National Gallery then existed, individual collections, such as that formed by the Duke of Richmond, were selected for study.

On the consolidation of the Society, the artists of London applied for permission to hold an exhibition in the Society's rooms. This permission was granted, and exhibitions continued to be held for several years. This annual inspection of the works of rival artists, who formed themselves into separate bodies, excited emulation, directed public attention toward their works, and ultimately secured for them the royal patronage and protection. These first exhibitions of pictures by native artists in the rooms of the Society of Arts may, therefore, be regarded as the origin of that exhibition of the Royal Academy which now forms one of the great events of the London season.

While the encouragement of art—pure and simple—thus formed the main object of the Society, investigation was directed toward many practical subjects related to the central idea. Endeavors were made to improve the materials employed by artists, and much attention was devoted to the various engraving processes as they gradually came into vogue. Wood-engraving, aquatint, and mezzotint, were the subject of anxious care, as were improvements in pigments, oils, and varnishes.

Bronze casting and chasing, iron-castings, and artistic metal-work, were also encouraged, and at a later date, when Alois Senefelder, an actor of Munich, discovered lithography, the new art was first introduced to this country under the auspices of the Society of Arts. Steel engraving was also first taken seriously in hand by Mr. Charles Warren, chairman of the Fine Arts Committee, who, at the suggestion of Mr. Gill, chairman of the Mechanics Committee, adopted a new method of treating steel plates. Previously to this, many attempts had been made to engrave on steel. Albert Dürer is said to have etched on steel, and there are four plates etched by this artist, impressions of which exist in the British Museum, and which in all books of art are recorded as having been executed on steel. In the attempts to revive this art, pieces of saw-blades were selected as the most promising material, but these efforts were attended with very little success. A Mr. Raimbach then endeavored to engrave on blocks of steel, but without achieving any material advance. Mr. Gill now drew the attention of Mr. Warren to the method employed at Birmingham in the manufacture of ornamental snuffers and other articles of cast-steel. The process employed at Birmingham was "to subject the steel, after having been rolled into sheets, to the process of decarbonization, by means of which it was converted to a very pure soft iron, being then made into the required instrument or other article. The ornamental work is engraved or impressed on the soft metallic surface, which, by cementation with proper materials, is again converted superficially into steel. Mr. Warren modified this process, and obtained thin plates of steel capable of being acted upon by acids and cut with the graver, without destroying the cutting edge of the tool—as was the case with the saw-blades. The resulting plate yielded a greatly-increased number of impressions." When brought to perfection, steel plates were found equal to the production of ten or twelve times the number of impressions yielded by copper plates. Capital was invested in the production of works of a high class, with the effect of spreading far and wide through the country myriads of prints calculated to elevate and improve the taste of the people. This process of conversion and reconversion of steel was soon afterward applied by Perkins to the production of steel rollers. These were first softened and then pressed into the engraved surface of a hardened steel block, and having acquired a design in relief were themselves hardened in their turn, and by being applied to softened steel plates produced almost indefinite multiplication of the original engraved plate. For commercial purposes this invention proved of immense value in the production of bank-notes, receipts, and postage-stamps.

To ignore the exertions of the Society of Arts in the direction of agriculture, and especially arboriculture, would be to omit an important page in its history. The introduction of new varieties of grasses and roots was sedulously encouraged, while drill-ploughs, the drainage of land, root-slicers, chaff-cutters, scarifiers, reaping-machines, and means of harvesting hay and corn in wet seasons, were all subjects of premiums. Big things and little things came in for their share of attention. In the early days of the Society sheep were marked with tar, to the great loss of wool-growers. The Society sought strenuously to modify and improve the mode of marking sheep, and meanwhile instituted a crusade against that bold invader, the Norway rat, who had recently overrun the country.

The preservation of timber was an object of earnest solicitude. In this age, when coal has effectually displaced wood as a heat-producer, and iron has been successfully applied to the construction of houses and ships, it is difficult to realize the anxiety of our forefathers at seeing whole forests destroyed for smelting purposes. For a long time past the work of destruction had been going on, when the Society of Arts stepped in to advocate the planting of trees on a large scale. The production of oak was a special object of the Society's attention, the planting of acorns was carried on to a very large extent, and gold medals for raising that description of timber were awarded to many noblemen and gentlemen, among whom were the Earl of Wilton, the Marquis of Tichfield, Mr. Morse, Mr. Curwen, and others. The cultivation of the ash—for which the Bishop of Llandaff received a gold medal—of the Scotch fir and larch, and of fruit-trees generally, received active encouragement. Under the auspices of the Society millions of trees were planted, to the enrichment and adornment of many previously-barren slopes. It is worthy of remark that to a neglect of these precautions is assigned an actual change of the climatic conditions of parts of Italy, and that the reduction of the Arno to an insignificant stream is ascribed to the reckless denudation of the mountains among which that historic river takes its rise. Travelers in Switzerland also have not failed to observe in the side valleys many relics of ancient mines, deserted, at last, because all the wood within carrying distance had been recklessly destroyed without any attempt being made to replace it by planting.

Considerable effort was devoted to encouraging the introduction and culture of spices into the British possessions. The cinnamon-tree was introduced into Jamaica; the nutmeg-plant into St. Vincent; the clove-tree into Trinidad; the mango and the bread-fruit tree were also planted in the West Indies. Attention was also directed toward such imports as were capable of discovery, manufacture, and culture, at home.

Cobalt was discovered in Cornwall; buff leather and its manufacture improved; copper and brass vessels were tinned; and hemp, flax, and madder, were cultivated for the use of our manufacturers. "Saw-mills were built; our fish-supply improved; and the curing of fish encouraged. Upon the fish-trade alone the Society expended many thousands of pounds, and succeeded in establishing a regular supply to the London markets."

During the greater part of its career the Society thus addressed itself to the task of fostering the useful arts. One condition, however, was, in the early days of the Society, rigidly insisted upon. The inventor who sought to obtain recognition of his discovery was obliged to forego the idea of patenting his work. What was given to the world by the assistance of the Society of Arts was to be given freely and openly for the benefit of all. Although this principle would find many and eloquent advocates at the present day, a period intervened during which it was found necessary to make concessions to patentees. The introduction of steam as a motive power led to a sudden and immense development of mechanical ingenuity, and swelled the prospective reward of a successful inventor to such large proportions that it was no longer probable that men would work for honor and glory alone. Eventually patentees were permitted to read papers before the Society of Arts, which, during the greater part of a century, continued to take an active interest in advancing the interests of science, and in affording aid and countenance to the other societies of less catholic tendencies, which sprang rapidly into existence. As has been already pointed out, the Royal Academy in its youth owed much to the Society of Arts; and it is worthy of note that, not only was the first exhibition of the works of rival artists held in the Society's rooms, but the first collection of photographs exhibited there in 1853. The Society still maintains a liberal tone, and is generous enough to grant the use of its handsome room to many societies for the purpose of holding their various meetings.

If the Society in the Adelphi merit a place of honor as a promoter of other societies, still more does it demand notice as the mother of exhibitions. Its exhibitional maternity was shown in this wise: In the year 1841 the Society of Arts, like many other originally active bodies, had shown signs of falling into decrepitude. For many of the purposes for which it was originally established, its office had been filled by other institutions, which, being less expansive in their views, appeared likely to act toward the mother-society like young ducks hatched by a barn-door hen, and to take to the stream of the future without consulting the feelings of their foster-parent. The Society was obviously falling into the sere and yellow leaf, and it was clear that something had to be done to rejuvenate it. A committee was appointed to revise the working of the Society, and that body recommended that a council to manage the affairs of the Society should be instituted. The committee in its report also gave expression to the conviction that "the Society cannot continue to exist on the plan of proceeding which is at present pursued," and that "the object of the Society is the promotion of the useful arts rather than the personal gratification of the members." It was further recommended that six committees should be established, of five members each, and many other valuable pieces of advice were tendered, but nothing came of all this for the time being. At length, however, measures were taken for obtaining a royal charter of incorporation, finally granted in 1847, and in the mean time it was proposed that an exhibition of English industry, analogous to those held abroad, should be instituted. The first action taken in this direction was an offer of special prizes for articles of manufacture, and a special fund was obtained for this purpose by private subscription. It was deemed necessary to stimulate the makers of English pottery to efforts toward an artistic combination of form and color. A committee of artists was appointed to adjudge the prize for a tea-service, and this was awarded to a set designed by "Felix Summerly," and manufactured by Messrs. Minton. The identity of "Felix Summerly" was then disclosed, and the Society's silver medal was presented to Mr. Henry Cole (who has since received the Companionship of the Bath), on the 12th of June, 1846. From this date a notable change came over the constitution of the Society. Yearly exhibitions were held. It is true that these were of a sectional character, and only proposed to illustrate certain branches of English industry; but it is not the less true that they were the immediate precursors of the great Exhibition of 1851. Prizes for modern industrial art were offered, and were eagerly competed for. Manufactures and artistic productions were got together at great expenditure of cash and industry, with the effect of rapidly increasing the number of members. In 1847 the members of the Society numbered scarcely five hundred; but within three years these numbers had tripled. But, in 1849, there were "croakers" in the camp. Not a few of the ruling spirits were inclined to "look back from the plough." As an instance of this may be quoted a recommendation of the Finance Committee of 1849, that "the exhibitions be discontinued," and another, passed in December of the same year, that "it is expedient to reconsider the policy of an Art Manufacture Exhibition in the year 1850." But the advanced spirits of the Society were not to be balked. Against the council of the ancients a formidable opposition was organized. Mr. Cole resigned his seat on the council, and, biding his time till the general meeting, effected a noteworthy *coup d'état*. On election-day the reactionary party were ousted by an immense majority, and an entirely new council elected. The Exhibition of Ancient and Mediæval Art was duly held, and resulted in a splendid success, and a complete revolution of the financial condition of the association. In 1850 the debts of the Society amounted to £2,402, an amount that was reduced in 1851 to £1,696, since when the Society has become not only solvent, but possessed of a large accumulation of capital, which—in the opinion of many of the members, now amounting to over 3,000—it is somewhat chary in dispensing. This great storm, which completely altered the condition of the Society of Arts, and culminated in the Great Exhibition of 1851, can thus be distinctly traced to Mr. Felix Summerly's "teacup."

The merit of initiating the idea of an international exhibition has been often warmly contested, but there is no longer any doubt that the original proposition was made to the committee of the Society of Arts in 1844, by Sir William Fothergill Cooke. There is no question that the idea of this gentleman was clearly that of an international exhibition, at that time declined by the committee of the Society of Arts, but at a later period adopted by that body with the sanction and coöperation of the late prince consort.

In the month of June, 1849, the secretary, Mr. J. Scott Russell, stated at the annual meeting, in the presence of the late prince consort, that, owing to the yearly increasing success of the Society's exhibition, the council had no doubt of their being able to carry out the plan originally proposed for holding a great national exhibition of the products of British industry in 1851. This statement led to frequent communications between his royal highness the president and various members, with the ultimate result of expanding the plan to international dimensions. The prince consort, as president of the Society, brought the scheme officially under the notice of the Government; but in the mean while the Society of Arts was not idle, and had already entered into a contract for building a convenient edifice, when a royal commission was issued. Mr. Scott Russell and Mr. (now Sir) Stafford Northcote were appointed secretaries. An executive committee was formed, consisting of "Henry Cole, Charles Wentworth Dilke the younger, George Drew, Francis Fuller, and Robert Stephenson, with Matthew Digby Watt as secretary." Meanwhile the Society of Arts had organized the financial arrangements necessary for carrying out the scheme, but the immediate connection of the Society with the exhibition now came to an end; the child had outgrown its nurse, and required nothing short of a royal commission to manage it. How well the Exhibition of 1851 was managed, and how, after the final adjustment of accounts, a surplus of £186,438 18*s.* 6*d.* remained in hand, are now matters of history, as well as the expenditure of that sum as part of the money devoted to the purchase and development of the Gore House estate.

Since the launching of the Great Exhibition, the Society of Arts has done much good work in promoting industrial art and encouraging inventive genius. It is true that much of its work has been taken out of its hands by the societies and museums to which it has given rise. Among these is the Photographic Society, whose inception was due to the exhibition organized by Dr. Diamond. The South Kensington Museum itself may be fairly regarded as an offshoot of the Mediæval Exhibition, while the Government Department of Science and Art is directly descended from the parent body. But the mission of the Society is not to repose on its laurels. It comes to the fore with a formidable list of premiums, at the head of which is a series of gold medals and prizes of £50 for improved cooking and warming apparatus; £500 are devoted to this purpose, and have been placed at the disposal of the Society by a single member. A large number of prizes in money, and many gold and silver medals, are also offered to inventors. Much interest is excited at the present moment concerning the award of the Albert Gold Medal, a prize established in memory of the late prince consort, to reward "distinguished merit in promoting arts, manufactures, or commerce." This medal was first presented in 1864, to Sir Rowland Hill, K. C. B., in 1865 to the late Emperor of the French, and in 1866 to Faraday. Since then, this distinguishing mark of the Society's appreciation has been conferred on Wheatstone, Whitworth, Liebig, Henry Cole, Henry Bessemer, and has this year been awarded by the council to Dr. C. W. Siemens, "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the arts; and for his improvements in the manufacture of iron; and generally for the services rendered by him in connection with economization of fuel in its various applications to manufactures and the arts."

For some years the Society's examinations, conducted through local institutions about the country, have assisted the spread of general education, and, now that this work is being more completely executed by the university local examinations, the Society has set on foot a scheme of technological examinations, which it is hoped may bear good fruit.

THE FIRST TRACES OF MAN IN EUROPE.

By Prof. ALBRECHT MUELLER.

TRANSLATED FROM THE GERMAN, BY PROF. JOSEPH MILLIKIN.

I.

IN a fine contrasting of Europe's wealth of historic memorials with his own country's yet new civilization, Washington Irving says of the former country, "Its every stone is a chronicle."

The remark is true, applied, as he meant it to be, to our older cities with their ancient edifices and defenses. But, belonging to a yet remoter past, are the remains of Roman and Celtic arts and architecture;

and in the pile-dwellings of our lakes and peat-beds we have relics of the Stone and Bronze eras, the beginnings of which lie beyond the reach of even tradition.

Nor is the limit yet attained. Thanks to the discoveries of the past few decades, we trace the existence of man back to a point antedating our earliest history by we know not how many centuries. Of this time, only a few bones and rudely-wrought stones are left as the witnesses—dumb, yet eloquent, and fulfilling in their way the saying, "If men hold their peace, the very stones will cry out."

The question was long since raised, whether traces of human existence had been, or were to be, found in the sand and gravel of the Post-Tertiary or Diluvial period, which immediately preceded the present. Some affirmed the finding of such remains in these, and the contemporaneous deposits of certain caves, while most geologists rejected such statements as erroneous, or, at best, unauthenticated, plausibly urging that ancient animal and recent human remains might easily have become intermingled. And such researches were discredited and discouraged by Cuvier's magisterial dictum, that man did not exist in the Diluvial period, and that it was, therefore, vain to look for evidences of his existence.

Some twenty years ago, however, M. Boucher de Perthes discovered a quantity of rude stone implements in the diluvial gravel-beds of Abbeville, in the valley of the Somme, in intimate connection with bones of mammoths. This discovery attracting much attention, in 1858 the French Academy of Sciences sent to the spot a committee of investigation, composed, be it not forgotten, of men utterly skeptical as to the fact at issue. This committee, strengthened by the accession of several English geologists, worked long and carefully at its task, and the Academy's discussions upon its reports were earnest and thorough; yet, the result was the complete confirmation of De Perthe's reputed discoveries, and of the conclusions he had drawn therefrom. Cuvier was confuted; the existence of man in the Diluvial period was established. Similar discoveries in the open country and caves of Germany, Spain, Italy, England, Belgium, and especially France, followed in rapid succession.

We cannot mention, much less describe, all the localities in which have been found the closely-conjoined remains of man and of animals, confessedly belonging to the drift or Diluvial period. We shall discuss only a few of the many cases, of which we may safely affirm that the often easy and common mingling of ancient with recent remains could not have occurred. To do this the more intelligently, we shall speak briefly first of the characteristics and deposits of the Diluvial and later prehistoric periods, and then of the human remains therein found.

The Drift or Diluvial Deposits.—The bottom-lands of our new valleys, of the Rhine, for example, chiefly consist of widely-extended deposits of loam, sand, gravel, and rocks, evidently brought from considerable distances by some vast current that once covered the lowlands, and even lesser hills; for, in the Rhine Valley this surface-layer is found at elevations of 300 to 600 feet above the present river-level. The bowlders are of various rocks that are not native to this region, but are found in the Juras, the mountains of the Black Forest, the Vosges, and especially the Alps, of whose mass these constitute a large proportion. A similar drift is found over the wide, rolling country between the Juras and the Alps, and indeed over nearly all the lowlands and valleys of Europe and the world. From the erroneous, but once universal belief, that it was produced by the Noachian Deluge, or the all-submerging flood of which the Sagas of so many nations are full, this deposit was early named the diluvium, or diluvial deposit. It consists, according to this view, of the detritus from mountain ranges, transported and scattered broadcast over lower levels by the Deluge.

This latest of geological formations rests upon the upper strata of the Tertiary, when they are present. In the Rhine Valley, however, it covers the Miocene or middle Tertiary; and in other regions, the chalk, the Jurassic, or even older formations. Upon the diluvium itself are built most of our cities, and in it will most of us be buried. The melted snows, the rains, and the waters of our streams, penetrate through its loose layers until the more impervious underlying clays (mostly Tertiary) arrest and hold them in readiness to supply our daily needs. The diluvium seldom yields much that is of mineral or industrial value, except the material of our tiles, brick, and mortar. In California, Brazil, Australia, and the Ural Mountains, however, its gravels are rich in gold, platinum, and jewels of various sorts, and in some localities tin-ores are found in it.

Geologists have been long occupied with the study of the producing causes of those vast floods, the effects of which are so strikingly seen in the pebbly plains and terraces of our river-valleys, and in the layers of sand and loam upon our uplands and hills. That there once were there masses of flowing water-currents, like, yet far vaster than, our present rivers, cannot be intelligently doubted. The absence of marine shells and the universal abundance of the remains of land-animals in the deposits in discussion forbid the belief that the sea covered our own and the adjacent continents during this latest of geological eras.

All the hypotheses advanced in explanation of the phenomena we have mentioned cannot be here adduced; we can only say that the great majority of recent geologists agree and assert that these immense streams were chiefly produced by the melting of snows and glaciers, that must then have extended not merely from the Alps and Pyrenees, as at present, but from the north, southward over a large portion of Europe; even the smaller ranges, such as the Vosges and Black Forest, then having each its glacier system.

Strongly in favor of this view are the erratic bowlders and blocks of stone, and the heaps and ridges of drift, so widely scattered over the mountains, plains, and valleys of Europe and North America, precisely similar as they are to those left by the retreat of the glaciers at the present time. And then, as now happens, the melting of floating icebergs, that were detached from the foot of glaciers as they reached the coast, strewed the ocean-bed with stones, gravel, and mud. The wide plains of Northern Germany are abundant in rocks and gravel from Scandinavia and Finland, for example. Our surface-deposits, therefore, are simply the detritus and *débris* of mountain-regions, transported thence by glaciers, and spread over our lower levels by the rivers that the melting of these glaciers produced.

This theory was first definitely propounded by Venetz, and has since been developed and verified by Charpentier, Agassiz, Forbes, and many others. Many geologists have opposed it from the first, but it may now be regarded as of practically universal acceptance, and as gaining constant confirmation from the immense number of facts annually observed and published.

The glacial theory implies the former prevalence in Europe and North America of a climate marked by much snow and rain, as well as ice; and this is confirmed by the characteristics of the fauna and flora of the time.[1] In addition to the waters produced by the melting of glacial masses then covering so large a portion of the Northern Hemisphere, the very great rainfall incident to such a climate would swell the volume of the great currents of the period—currents not of transient flow like mere mountain-torrents, or our local freshets, but that swept on for centuries or millenniums. Minor additional inundations, also, would result from risings and subsidences of the earth's surface in given localities, from the damming of the waters in the valleys by glaciers and avalanches, from the sudden emptying of mountain-lakes thus formed, and possibly from earthquakes. It is to these various causes that we may attribute the washing out of the lower terraces of our present river-valleys.

The great currents by which we explain the various phenomena of the drift are due to the glaciers of this Ice period, then; and this suggests the further question, What produced the Ice period itself, the long-prevailing low temperature of regions now warm or temperate? A vast array of observations commends to the attention the following answer:

There was then a distribution of land and water upon the earth very different from the present, and, as the result of it, a different system and direction to the currents of the sea and air. And there are

[1] Prof. Oswald Heer has given, in his "Urwelt der Schweiz," a description, at once scientific and entertaining, of the Swiss fauna and flora of the Drift period. In his valuable studies upon the diluvial flora, Count Gaston de Saporta concludes in favor of a climate in this period marked rather by extreme moisture than by extreme cold.

influences by which the climate of a given region is vastly controlled; that is, it is to the warmth of the waters of the Gulf Stream that the present mildness of the climate of the islands and coast-countries of Northern Europe is owing.

Adhemar has not been without followers, indeed, in the attempt to prove that the low temperature of the Ice period was due to astronomical rather than terrestrial causes—namely, to the change, in periods of 21,000 years, of the obliquity of the earth's axis to its orbit, and the still slower change in the eccentricity of that orbit itself. From the coöperation of these two causes, it is said the winters of either hemisphere would become longer and the summers shorter, and *vice versa;* and so on, in alternate periods. For example, the earth's axis reached the position most favorable to the climate of the Northern Hemisphere in A. D. 1248, since which time we have been advancing toward a new Ice period; whereas, antarctic regions then passed the point of greatest intensity of cold. Even the relative distribution of land and sea, it is affirmed, would be changed by these alternating accumulations and diminutions at either pole. To all this, we can here merely reply that if these astronomical facts have any influence whatever upon the earth's climate, we are wholly ignorant as to its amount; and since Herschel's time astronomers have been disinclined to ascribe to them any considerable share in the production of climatic variations.[1]

But there is abundant evidence that during the Drift period there took place extensive and considerable elevations and subsidences of the earth's surface. Such elevations are still going on, as witness the rise of the coast-terraces of Scotland, Sweden, Norway, Sardinia, Sicily, and other lands, to a height far above the present sea-level. Confusion here is easy, however, and it must not be forgotten that the retreat of the shore-line would be apparently and practically an emergence of the land, although the latter remained fixed all the time; and curiously, apparent encroachments of the sea upon the shore may be an actual subsidence of the shore itself.

A study of the drift deposits, and the organic remains found therein, compels the belief that at one part of that period the lowlands of Europe—i. e., Holland, the plains of Northern Germany, and parts of Russia, Great Britain, Denmark, Sweden, and Norway—were covered by the North and Baltic Seas, which, thus united and enlarged, extended southward through Russia and Siberia, and possibly connected the Black and Caspian Seas. The Desert of Sahara was also under water, as Desor and Escher show. The shells of marine species yet mostly extant, now found in the extensive lowlands of North America, show these also to have been submerged.

In an earlier epoch of the Diluvial period, however, that is, previous

[1] The scientific reader need not be informed that though Adhemar is not followed as to all details, many of the best modern (especially English) scientists agree in ascribing a prominent influence to these astronomical factors in the production of climate.—TRANSLATOR.

to the time of the above-mentioned submergence of so much of Europe, the countries mentioned were so high above the sea-level of the time that the bottom not only of the Straits of Dover but of a large portion of the North and Baltic Seas was dry ground. These waters have a depth even now of only some 200 feet—rarely of 250 feet—so that an elevation geologically very slight would expose the bottom of these shallow seas. So Ireland was then connected with Great Britain, and the latter with France; while Africa and Europe were joined by bridges of land, so to speak, e. g., by way of Gibraltar, and again by way of Sicily and Malta. As a natural result and confirmation of the latter instance, we find on these islands and the contiguous main-lands the remains of mammals peculiarly African, especially certain species of elephants. These strips of dry land divided the Mediterranean into several inland seas. If man existed in that remote epoch, as many arguments tend to prove, he could cross dry-shod between Africa and Europe, as did the animals just mentioned, and was a witness of a distribution of land and water in Europe and adjacent lands widely different from that of our day. There was also going on about him and beneath his feet the slow rising and sinking of vast continental and insular territories—processes requiring thousands of years for their accomplishment—and, if man's existence during them be admitted, constituting another proof of the great antiquity of the race.

It is to these slowly-effected but most important alterations in both the contour and relief of the surface that we must ascribe the great changes of the climate, not alone of separate localities, but of entire continents; and this conclusion we will finally use in explanation of the varied phenomena of the Ice period, with which we have specially to do. The Ice *period*, we have said; but, without attaching much importance to the astronomical influences previously mentioned, we are compelled to believe in a succession of Ice periods, the evidences of which are believed to be furnished in the several series of deposits that are assigned to corresponding epochs.

During the latter portion of the Diluvial period the earth acquired substantially the same relief as it has at present. The chief mountain-ranges, the Juras, the Vosges, the Black Forest, the Pyrenees, the Alps, etc., were then about what they are now, though somewhat higher relatively both to the sea-level and to the subjacent plains; for, by the operation of various natural forces, peak after peak has been either shattered and cast down, or slowly worn away, and their *débris*, carried down in the form of sand, gravel, or larger masses, have gradually but considerably raised the level of the valleys and plains.

We now proceed to consider the several subdivisions of the Diluvial and the Post-diluvial but prehistoric periods, and the traces of human existence belonging to each.

1. The Age of Mammoths.—The loëss, the layer of calcareous loam, sand, and gravel, with which our hills are covered, is full of the

shells of small land-snails, mostly extinct in this region,[1] though yet extant in high mountain-regions. So abundant are they as to give to this soil the popular name of "snail-shell soil." The preservation of animal and vegetable remains in the gravelly deposits of our lowlands is naturally rare, comparatively, they being, for the most part, soon destroyed in beds so loose and permeable by air and water. And yet in Germany, France, Belgium, England, Switzerland, and other parts of Europe, there are found, in this very formation, the bones and teeth of mammals, mostly of long-extinct species, the nearest congeners of which are now native either to Africa and Asia, or else to the colder parts of Northern Europe and America, and the higher Alps and Pyrenees. Bones of these same species, and hence of the same geological era, are found in numerous caves as well; some species, indeed, being almost wholly thus preserved. Among the better known of these caves we may cite those of the Suabian and Franconian Juras, and the Gailenreuther Cave, from which nearly every important cabinet of Europe has been enriched.

Prominent among the buried mammals of the drift are the mammoth (*Elephas primogenius*), the immense teeth and tusks of which are so often exposed by our river-currents, and during excavations for buildings, besides the many entire carcasses found in the ice and frozen soil of Siberia. In many of these latter cases, the skin, the hair proper, a reddish-brown, long, hairy wool, and a mane still longer, are kept in perfect preservation. The latest discovered of these was visited by the naturalist Schmidt, but the wild beasts had anticipated his coming, and devoured most of the flesh. Middendorf estimates the number found in that region at several thousands. Their tusks—considerably curved, and eight to ten feet in length—are in quantities still sufficient to be the staple of a not inconsiderable trade in ivory. Brandt believes the mammoth to have been somewhat larger than the East Indian elephant of to-day, with tusks of much greater curvature.

Next in size to the mammoth was a rhinoceros, characterized by two horns and an osseous nasal septum (*Rhinoceros tichorhinus*). Its teeth are often met with, and, some fifteen years ago, an almost entire and perfectly preserved carcass was found in the ice on the river Wilni in Siberia.[2]

Equally abundant with the remains of these two are those of the cave-bear (*Ursus spelæus*), which was about the match in size of the polar bear. It is found in the drift of the open country, and in the caves of the same age.

The peat-beds of Ireland yield entire skeletons of the giant-elk

[1] The reference is to the author's own picture of the Upper Rhine Valley, of course.—Translator.

[2] Dana ("Manual of Geology," American edition of 1863, page 561) mentions a similar discovery in 1772, in the same locality. This species of the rhinoceros, like the mammoth, was protected by long, woolly hair.—Trans.

(*Cervus ungaceros* or *C. Hibernicus*), the ten or twelve foot span of whose antlers must have put him to great disadvantage, and so proved one of the causes of his extinction.

Then comes the primitive ox (*Bos primogenius*), generally regarded as the progenitor of our present race of cattle, and found running wild in the forests of Germany as late as Cæsar's time.

The hippopotamus, found mostly in Italy and the south of France, is more rare. It is clearly allied to the species that now inhabit the tropics.

Remains of the cave-tiger or cave-lion (*Felis spelæa*)[1] have recently been found in various localities, though formerly but rarely.

Very significant as to the climate of Europe in this age is the presence of such species as the reindeer, musk-ox, and lemming,[2] which now inhabit only high northern latitudes, and of other species which are now peculiar to the moister heights of the Alps, e. g., the chamois, mountain-goat, and marmot. These were all once native to our plains and uplands.

The North American and European mammals of this period are very nearly identical. In place of and sometimes in addition to the mammoth, however, America had the equally immense mastodon (*Mastodon giganteus* or *Ohioticus*). Six almost perfect skeletons of it were discovered in Warren County, in Western New York, in 1845.[3] Their rude study of its remains suggested to the North American Indians the name of "Father of Buffaloes." The entire genus is wanting in the Diluvium of Europe, though several of its smaller species are represented in the Tertiary.

So far as is yet known, these are the most important contemporaries of primeval man in Europe. They are his competitors and enemies in the "struggle for existence," to meet which he must needs have had all his powers of body and of mind.

Now, it is important to remember that we find both these extinct animals' remains and man's bones and implements in the same deposits and caves of the Diluvial period; that is, that these animal and these human relics were contemporaneous, first as to their deposition, and

[1] The most recent studies ally it rather to the tiger than to the lion family.

[2] The Lapland or Norwegian marmot (*Myodes lemmus* and *M. torquatus.*)—Trans.

[3] The author has fallen into confusion, certainly, as to localities, and probably as to facts: 1. Warren County, New York, is in the east-northeast part of the State; 2. I have searched vainly for mention of precisely such a discovery as the text describes. In 1844, and in Warren County, *New Jersey*, was found the skeleton of the young female mastodon now at Cambridge, Mass., with the skulls of four others.

Three perfect skeletons were afterward dug from swamps near Newburg, New York, and described by Dr. Warren in his splendid work, "The Mastodon Giganteus of North America," (second edition, Boston, 4to, 1855). These are the richest "finds" of which I have been able to find any account.

On the distinction between the mammoth and the mastodon, and their several species, characteristics, remains, and place in paleontology, and Indian legends, *see* a capital article in the *American Naturalist*," vol. ii., pp. 23, *et seq.*—Trans.

secondly as to their unearthing and exposure to our observation. And how rapidly one such discovery follows another may be partly inferred from the fact that some years since a magazine[1] was founded in Paris, devoted to this special topic; many courses of lectures upon it were delivered in the various cities of Europe; and for some years international congresses have been annually held, and societies and periodicals established, for the discussion of it and cognate subjects. The literature of the subject is already voluminous.

Let us revert to M. Boucher de Perthes's discoveries in the drift of the Somme Valley. Begun in 1841, they were described by him in a work published in 1847—a work then too little appreciated. But when, in 1858, and in the same locality, he discovered a human skull and various stone implements, in intimate association with remains of the various animals of that period, the attention of the French Academy was aroused, and the study of historical geology received a new impetus. Some, indeed, see in the discovery of De Perthes only a cheat, or at best a mistake, and doubt the antiquity of this skull and its contemporaneousness with the animals found with it. The entire collection is proved to be of the same age, however, by the whole manner of the intermingling of human skulls, flint knives of unmistakable human workmanship, and animal remains; and the genuineness of De Perthes's discoveries and the validity of the inferences drawn from them are confirmed by many similar ones made since then in localities widely separated, both from that in which he worked and from each other.

What we said of the preservation of animal remains we repeat as applicable, in an even higher degree, to that of human remains, in *débris* so found; it is possible only as the result of a conjunction of favoring circumstances that must be comparatively very rare. And yet many such instances are on record. As early as 1825, Ami Boul, from the loëss of the Lahr region in the Breisgau, discovered a human skeleton, and two years afterward a human skull,[2] with bones of the mammoth and other diluvial animals, from the loëss at Eguisheim, near Colmar. The study of the deposit in which the latter of these two discoveries was made, with the relative positions of the remains themselves, and the chemical analyses of them by Dr. Scheurer-Kestner, of Thann, leave no room for doubt that the man and the animals were synchronous, both in life and in the deposition of their remains.

And many localities yield human bones and implements mingled with remains of diluvial animals, especially of the mammoth, the rhinoceros of the species previously described, and the cave-bear. Especially rich in these combined relics are caves of Lenu and Sombrive, in the department of Ariége, France, and of Engihoul and Engis, near Lüttich (Liège), Belgium. The contents of the latter two

[1] *Matériaux pour servir à l'histoire de l'homme.*

[2] Elaborately described by Dr. Fandel, of Colmar.

caves were described by Schmerling, in his admirable but neglected works, some thirty-five years ago.

The Neanderthal cave[1] has become celebrated. An entire human skeleton of good size and proportions, save its ape-like, low-browed skull, was discovered here in 1856,[2] a full account of which was given by Dr. Fuhlrott. This discovery, since become the occasion of so much discussion, indicates quite clearly the existence in that remote period of a race of men of marked characteristics, and in some peculiarities closely resembling certain now-living Australian tribes. The skull is not nearly of so high a type as that from the Engis cave just mentioned.

Of exceptional interest, also, is the burial-place at Aurignac, in the department of Haute-Garonne, in Southern France. It was accidentally discovered in 1852, but first scientifically described in 1861, by Lartet. There, in a cave closed by a vertical slab of stone, which was itself hidden by accumulated stone fragments dropped from the cliff above, were found no less than seventeen human skeletons, mingled with bones of the cave-bear, cave-lion, mammoth, rhinoceros, giant-elk, and other now-extinct diluvial animals, weapons of wrought-flint and implements of bone, stag's-horn, and ivory—articles probably buried with the dead for use in the life beyond the grave; in the belief of which Sir Charles Lyell, in his work on the "Antiquity of Man," quotes as pertinent the well-known lines from Schiller's "Nadowessian Death-Song:"

> "Here bring the last gifts—and with these
> The last lament be said:
> Let all that pleased, and yet may please,
> Be buried with the dead.
>
> "Beneath his head the hatchet hide
> That he so stoutly swung:
> And place the bear's fat haunch beside—
> The journey hence is long.
>
> "And let the knife new sharpened be,
> That, on the battle-day,
> Shore with quick strokes—he took but three—
> The foeman's scalp away!"[3]

In exact agreement with one of these lines, the thigh-bones of the cave-bear were actually found laid beside some of the skeletons of this cave. Not a trace of pottery was found here. Under the *débris* mentioned as lying just outside of the door of the cave were ashes, charcoal, and bones of the species found inside, all suggestive of the notion that the funeral-feast may have been here celebrated. This heap con-

[1] Near Hoehdal, a village on the railroad between Düsseldorf and Elberfeld.—Trans.

[2] Lyell gives the date 1857.—Trans.

[3] I have given Sir E. L. Bulwer's version.—Trans.

tained bones of other yet extant animals also, viz., the aurochs,[1] reindeer, and stag.

Most of the human relics of any sort have been found in the more recent layers of the drift. They have been discovered, however, not only in the older drift, but also, though very rarely, in the underlying Tertiary. For instance, in the upper Pliocene at St.-Prest, near Chartres, were found stone implements and cuttings on bone, in connection with relics of a long-extinct elephant (*Elephas meridionalis*) that is wholly lacking in the drift. During the past two years the evidences of human existence in the Tertiary period—i. e., previous to the age of mammoths of the Diluvial period—have multiplied, and by their multiplication give cumulative confirmation to each other. Even in the lower strata of the Miocene (the middle Tertiary) important discoveries of stone knives and bone-cuttings have been made, as at Thenay, department of Marne-et-Loire, and Billy, department of Allier, France. Prof. J. D. Whitney, the eminent State geologist of California, reports similar discoveries there also. So, then, we may believe that before the last great upheaval of the Alps and Pyrenees, and while the yet luxuriant vegetation of the then (i. e., in the Tertiary period) paradisaic climate yet adorned Central Europe, man inhabited this region.

Such discoveries relegate the beginning of human life to a time the remoteness of which is to be estimated not by years, but by millenniums. It is of course difficult to even approximate to a date so distant, but there is reason to believe it must have been at least 50,000 years ago. Even the Indian, Persian, Assyrian, and Egyptian civilizations, with their languages, literatures, and achitectural monuments, required a long, long time for their development from their rude beginnings, and hence a far longer time for the whole lifetime of that race. For a people remains a long time in its primitive condition, and its first progress is very slow, as the savage and semi-savage races of to-day prove to us. But the progress of a people well endowed being begun, it advances with giant strides, at a rate increasing in geometrical ratio.

It were vain to draw positive or detailed conclusions as to the grade of culture attained by the man of the Diluvial period from the comparatively few relics of his life as yet found in the drift and caves. These data are yet too few, slight, and disconnected, for that. For instance, while some of the skulls (that from the Neanderthal especially) indicate an ape-like race, of short stature, others are of a type far higher, and scarcely differing from those of European tribes yet living.

A human jaw-bone, of remarkable cast, was lately taken from the Trou de la Nanlette, a cave on the river Lesse, near Dinant, during

[1] Or Lithuanian bison. A few living specimens of this animal are carefully preserved by the Emperor of Russia.—Trans.

excavations conducted by M. Edouard Dupont, under the auspices of the Belgian Government. The dental structure is a striking mean between the ordinary human type and that of the ape. Other Belgian and French caves have yielded similar remains, while on the other hand the remains of an ape (*Dryopithecus fontani*), with a dental structure strikingly anthropoid, were found in the upper Miocene beds of the Tertiary at Sansans, department of Gers, in Southern France. In the Trou de la Naulette long bones of animals in many instances were split longitudinally, for the easy extraction of the marrow. They thus become interesting as early traits of human industry and habits. From the remains as yet found we infer the existence in Europe of a race originally rather ape-like, but progressing toward a build and culture in the complete sense human.

And this is in perfect consonance with the general progress of organic life during the long marches of the various geological eras. The present is thus the era of the highest types. We are still told by many, however, that although every thing in Nature—stone, plant, animal—is stamped with tokens of the law and proofs of the fact of gradual development, man, though equally with them a link in the chain of being—man, forsooth, must have come from the hand of his Creator *immediately*, and perfect from the first.

But let us not draw, from facts as yet comparatively few and very scattered, conclusions which the very first new discovery may reverse. And seeing how few are the human remains yet found in these ancient layers, it is not strange that many hesitate to follow those who already extend the principles of the Darwinian hypothesis to man, and find our very own brethren in the anthropoid apes—brethren sprung from a common ancestry, but immeasurably outstripped by us in the long, long course of a development begun in a previous geological era. But those who accept Darwinism as applied to the animal and vegetable kingdoms, implying as that theory does the progress of organic life from low to higher, from simple to more complex forms and functions—these can hardly resist the conclusion that man also, as to his physical part at least, is but a highly-developed member of the animal kingdom. And, so far as they go, the data of geology favor that view.

Although the anthropoid apes resemble man in structure more closely than they resemble their lower congeners, still the lowest men are far superior, in mental character at least, to these highest apes. And we insist that it is a legitimate subject of inquiry whether the wide chasm now separating the highest apes from the lowest men has existed from the beginning, or whether the spiritual powers of the latter have been developed from the rude beginnings of intellectuality in the former.

The indications are that the primeval man of Europe and his nearer descendants were of short stature. The popular notion, that the present generation is physically weaker and smaller than the primitive or ancient, is not only utterly unfounded, but there is abundant evidence that the reverse is true. Most of us would be amazed if not shocked at a true and life-size portrait of the real Eve, "mother of all living." We often hear, indeed, of giants' bones here and there dug up, but intelligent examination invariably proves them to have belonged to the mammoth or other animal.[1] A singular blunder of the kind shows the real value of such reputed discoveries. Years ago, a skeleton was dug from the calcareous shale at Oeningen, which the veteran *savant* Scheuchzer confidently christened "*Homo diluvii testis*"—the man who saw the flood. Casts of it were made for various museums, and, in full faith in the legitimacy of the name, one Deacon Müller was moved to write some most pious and edifying lines about it. Unfortunately, the first competent study of the skeleton proved it to be that—not of an ancient sinner, but of a large salamander, closely resembling the Giant Salamander of Japan. Yet, to this day, every casually unearthed petrifaction, found no matter where or in what relations, is to many a memorial of the Noachian Deluge. Thus, theories which science has long ago refuted and dismissed from further consideration, are persistently held fast and reaffirmed.

If we are to attain even an approximate notion of the grade of culture reached by what we must provisionally regard as the autochthonic, primitive man of Europe, we must infer it from the yet preserved works of his hands rather than from the lamentably few osseous remains yet found with them. He had various articles of bone and horn, clubs and slings, and knives and spear-heads, some of which were long and slender, some short and round, chipped into shape out of flint and jasper. He had no pottery as yet, and no wrought metals. He split the longer bones of animals used as food, the better to get at the marrow; and this was not only eaten, but probably then, as by many savage races at present, employed as an unguent also. The domestication of animals was evidently not yet begun—even the horse being used neither for draught nor for carrying. That primitive race contented itself with the wild products of the forest, the chase, and the waters, as to food, and for dwellings used caves, generally in cliffs difficult of access and easy of defense, like those on the river Lesse, near Namur.

We are to picture to ourselves, then, a people very like the Esquimaux in circumstances and activities. It lived in our own Europe, but Europe covered to a considerable extent with glaciers, and keeping up a hard and continuous resistance both to wild beasts and the rigors of a climate at once very cold and very damp. The mammoth and rhinoceros, as we have seen, were protected by thick, woolly hair, and fed upon the twigs of the abundant conifers, as fragments yet found in the interstices of the teeth and ribs show. We must not be misled

[1] Our own papers often tell us of bones or skeletons of men who must have been eight or ten feet in height, but in each case a tape-line and a little knowledge of anatomy reduce them to ordinary proportions.—Trans.

as to the then climate of Europe by thinking of that of the present habitat of the elephant and rhinoceros. Even now the Bengal tiger traverses Asia as far north as latitude 52°, and the lion and tiger are frequently met with when snow and ice are present.

The tools and weapons of the man of this age were simple indeed, but no mean skill was employed in their manufacture and use. Even with our many and marvelous inventions, one of us, cast away upon some uninhabited shore, could hardly manifest more self-helpfulness. And the manner in which the dead were buried—one of the common modes of expressing a race's faith in a future life—shows the possession of some degree of spiritual development.

Such are "the earliest traces of man in Europe," the slight, sparse indications of his existence in the Tertiary or next preceding formation excepted. These traces of man in the Diluvium belong to the period geologically the most recent indeed, yet even it is separated from our own time by a gulf of many thousands of years. The rhinoceros, primitive ox, giant-elk (*Megaceros Hibernicus*), and cave-bear, are prominent among the contemporaries of this primitive man, but the characteristic animal of the time was the mammoth. Hence the name of the first age of Man—the "Age of Mammoths."

We will vainly seek in this earliest man for evidences of that creaturely perfectness which, according to the common view, he must have inherited from his first parents in paradise—the charming paradise of Genesis, of art, and of poetry. For the geologist, the fruits of the truly paradisaic epoch grew in a far remoter past, when Europe was adorned with the palm and cinnamon-tree, and all the exuberant vegetation of the middle Tertiary period, whence our peat-beds are formed; when, instead of man, the ape, or possibly a man not much superior to the ape, stood at the head of God's earthly creatures.

Having answered the question as to man's first traces in Europe, we might now bring our treatise to a close. But, to gain an adequate notion of the antiquity of our race, and of its progress during the successive ages, we proceed to a cursory review of the succeeding eras of prehistoric human existence.

THE ATMOSPHERE IN RELATION TO FOG-SIGNALING.

By JOHN TYNDALL, LL. D., F.R.S.

II.—*Action of Hail and Rain.*

IN the first part of this article it was demonstrated that the optic transparency and acoustic transparency of our atmosphere were by no means necessarily coincident; that on days of marvelous optical clearness the atmosphere may be filled with impervious acoustic clouds, while days optically turbid may be acoustically clear. We have now to consider, in detail, the influence of various agents which have hitherto been considered potent in reference to the transmission of sound through the atmosphere.

Derham, and after him all other writers, considered that falling rain tended powerfully to obstruct sound. An observation on June 3d has been already referred to as tending to throw doubt on this conclusion. Two other crucial instances will suffice to show its untenability. On the morning of October 8th, at 7.45 A. M., a thunder-storm, accompanied by heavy rain, broke over Dover. But the clouds subsequently cleared away, and the sun shone strongly on the sea. For a time the optical clearness of the atmosphere was extraordinary, but it was acoustically opaque. At 2.30 P. M. a densely black scowl again overspread the heavens to the west-southwest. The distance being 6 miles, and all hushed on board, the horn was heard very feebly, the siren more distinctly, while the howitzer was better than either, though not much superior to the siren.

A squall approached us from the west. In the Alps or elsewhere I have rarely seen the heavens blacker. Vast cumuli floated to the northeast and southeast; vast streamers of rain descended in the west-northwest; huge scrolls of cloud hung in the north; but spaces of blue were to be seen to the north-northeast.

At 7 miles' distance the siren and horn were both feeble, while the guns sent us a very faint report. A dense shower now enveloped the Foreland.

The rain at length reached us; falling heavily all the way between us and the Foreland. But the sound, instead of being deadened, rose perceptibly in power. Hail was now added to the rain, and the shower reached a tropical violence, the hailstones floating thickly on the flooded deck. In the midst of this furious squall both the horns and the siren were distinctly heard; and as the shower lightened, thus lessening the local pattering, the sounds so rose in power that we heard them at a distance of 7½ miles distinctly louder than they had been heard through the rainless atmosphere of 5 miles.

At 4 P. M. the rain had ceased, and the sun shone clearly through the calm air. At 9 miles' distance the horn was heard feebly, the siren clearly, while the howitzer sent us a loud report. All the sounds were better heard at this distance than they had previously been at 5½ miles; from which, by the law of inverse squares, it follows that the intensity of the sound at 5½ miles' distance must have been augmented at least threefold by the descent of the rain.

On the 23d of October, our steamer had forsaken us for shelter, and I sought to turn the weather to account by making other observations on both sides of the fog-signal station. Mr. Douglas, the chief-engineer of the Trinity House, was good enough to undertake the observations northeast of the Foreland; while Mr. Ayres, the assistant engineer, walked in the other direction. At 12.50 P. M. the wind blew a gale, and broke into a thunder-storm with violent rain. Inside and outside of the Cornhill Coast-guard Station, a mile from the instruments, in the direction of Dover, Mr. Ayres heard the sound of the siren through the storm; and, after the rain had ceased, all sounds were heard distinctly louder than before. Mr. Douglas had sent a fly before him to Kingsdown, and the driver had been waiting for fifteen minutes before he arrived. During this time no sound had been heard, though forty blasts had been blown in the interval; nor had the coast-guard man on duty, a practised observer, heard any of them throughout the day. During the thunder-storm, and while the rain was actually falling with a violence which Mr. Douglas describes as perfectly torrential, the sounds became audible, and were heard by all.

To rain, in short, I have never been able to trace the slightest deadening influence upon sound. The reputed barrier offered by "thick weather" to the passage of sound was one of the causes which tended to produce hesitation in establishing sound-signals on our coasts. It is to be hoped that the removal of this error may redound to the advantage of coming generations of seafaring men.

Action of Snow.—Falling snow, according to Derham, is the most serious obstacle of all to the transmission of sound. We did not extend our observations at the South Foreland into snowy weather; but a previous observation of my own bears directly upon this point. On Christmas-night, 1859, I arrived at Chamouni, through snow so deep as to obliterate the road-fences, and to render the labor of reaching the village arduous in the extreme. On the 26th and 27th it fell heavily. On the 27th, during a lull in the storm, I reached the Montanvert, sometimes breast-deep in snow. On the 28th, with great difficulty, two lines of stakes were set out across the glacier, with the view of determining its winter motion. On the 29th, the entry in my journal, written in the morning, is, "Snow, heavy snow; it must have descended through the entire night, the quantity freshly fallen is so great."

Under these circumstances I planted my theodolite beside the Mer de Glace, having waded to my position through snow which, being dry, reached nearly to my breast. Assistants were sent across the glacier with instructions to measure the displacement of a transverse line of stakes planted previously in the snow. A storm drifted up the valley, darkening the air as it approached. It reached us, the snow falling more heavily than I had ever seen it elsewhere. It soon formed a heap on the theodolite, and thickly covered my own clothes. Here, then, was a combination of snow in the air, and of soft, fresh snow on the ground, such as Derham could hardly have enjoyed; still through such an atmosphere I was able to make my instructions audible quite across the glacier, the distance being half a mile, while the experiment was rendered reciprocal by one of my assistants making his voice audible to me.

The flakes here were so thick that it was only at intervals that I was able to pick up the retreating forms of the men. Still the air through which the flakes fell was continuous. Did the flakes merely yield passively to the sonorous waves, swinging, like the particles of air themselves, to and fro as the sound-waves passed them? Or did the waves bend by diffraction round the flakes, and emerge from them without sensible loss? Experiment will aid us here by showing the astonishing facility with which sound makes its way among obstacles, and passes through tissues, so long as the continuity of the air in their interstices is preserved.

A piece of mill-board or of glass, a plank of wood, or the hand, placed across the open end t' of the tunnel $a\ b\ c\ d$ (*see* page 689), intercepts the sound of the bell, placed in the padded box P, and stills the sensitive flame k (described in the last article).

An ordinary cambric pocket-handkerchief, on the other hand, stretched across the tunnel-end produced hardly an appreciable effect upon the sound. Through two layers of the handkerchief the flame was strongly agitated; through four layers it was still agitated; while through six layers, though nearly stilled, it was not entirely so.

Dipping the same handkerchief into water, and stretching a single wetted layer across the tunnel-end, it stilled the flame as effectually as the mill-board or the wood. Hence the conclusion that the sound-waves in the first instance passed through the interstices of the cambric.

Through a single layer of thin silk the sound passed without sensible interruption; through six layers the flame was strongly agitated; while through twelve layers the agitation was quite perceptible.

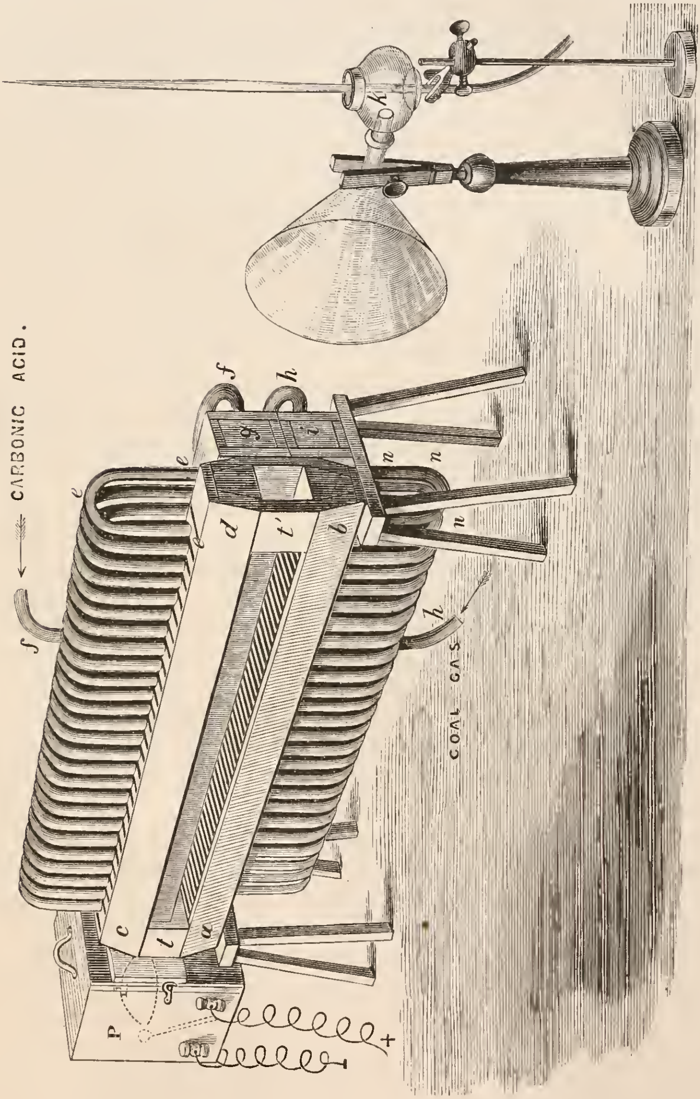
A single layer of this silk, when wetted, stilled the flame.

A layer of soft lint produced but little effect upon the sound; a layer of thick flannel was almost equally ineffectual. Through four layers of flannel the flame was perceptibly agitated. Through a single layer of green baize the sound passed almost as freely as through air; through four layers of the baize the action was still sensible. Through a layer of close hard felt, half an inch thick, the sound-waves passed with sufficient energy to sensibly agitate the flame. I did not witness these effects without astonishment.

A single layer of thin oiled-silk stopped the sound and stilled the flame. A single layer of gold-beater's-skin did the same. A leaf of common note-paper, or even of foreign post, stopped the sound.

The sensitive flame is not absolutely necessary to these experiments. Let a ticking watch be hung six inches from the ear, a cambric handkerchief dropped between it and the ear scarcely sensibly affects the ticking, a sheet of oil-skin or an intensely heated gas column cuts it almost wholly off.

But, though oiled-silk, foreign post, and even gold-beater's-skin can stop the sound, a film sufficiently thin to yield freely to the aërial pulses transmits it. A thick soap-film produces an obvious effect upon the sensitive flame, a very thin one does not. The augmentation



Apparatus for showing the Influence of a Non-homogeneous Atmosphere on the Transmission of Sound.

of the transmitted sound may be observed simultaneously with the generation and brightening of the colors which indicate the increasing thinness of the film. A very thin collodion-film acts in the same way.

Acquainted with the foregoing facts regarding the passage of sound through cambric, silk, lint, flannel, baize, and felt, the reader is prepared for the statement that the sound-waves pass without sensible impediment through heavy artificial showers of rain, hail, and snow. Water-drops, seeds, sand, bran, and flocculi of various kinds, have been employed to form such showers: through all of these, as through the actual rain and hail already described, and through the snow on the Mer de Glace, the sound passes without sensible obstruction.

Action of Fog: Observations in London.—But the mariner's greatest enemy, fog, is still to be dealt with; and here for a long time the proper conditions of experiment were absent. Up to the end of November we had had frequent days of haze, sufficiently thick to obscure the white cliffs of the Foreland, but no real fog. Still those cases furnished demonstrative evidence that the notions entertained regarding the reflection of sound by suspended particles were wrong; for on many days of the thickest haze the sound covered twice the range attained on other days of perfect optical transparency. Such instances dissolved the association hitherto assumed to exist between acoustic transparency and optic transparency, but they left the action of dense fogs undetermined.

On December 9th a memorable fog settled down on London. I addressed a telegram to the Trinity House suggesting some gun-observations. With characteristic promptness came the reply that they would be made in the afternoon at Blackwall. I went to Greenwich in the hope of hearing the guns across the river; but the delay of the train by the fog rendered my arrival too late. Over the river the fog was very dense, and through it came various sounds with great distinctness. The signal-bell of an unseen barge rang clearly out at intervals, and I could plainly hear the hammering at Cubitt's Town, half a mile away, on the opposite side of the river. No deadening of the sound by the fog was apparent.

Through this fog and various local noises, Captain Atkins and Mr. Edwards heard the report of a 12-pounder cannonade with a 1-lb. charge distinctly better than the 18-pounder with a 3-lb. charge, an optically clear atmosphere, and all noise absent, on July 3d.

Anxious to turn to the best account a phenomenon for which we had waited so long, I tried to grapple with the problem by experiments on a small scale. On the 10th I stationed my assistant with a whistle and organ-pipe on the walk below the southwest end of the bridge dividing Hyde Park from Kensington Gardens. From the eastern end of the Serpentine I heard distinctly both the whistle and the pipe, which produced 380 waves a second. On changing places with my assistant, I heard for a time the distinct blast of the whistle only. The deeper note of the organ-pipe at length reached me, rising sometimes to great distinctness, and sometimes falling to inaudibility.

The whistle showed the same intermittence as to period, but in an opposite sense; for when the whistle was faint the pipe was strong, and *vice versa.* To obtain the fundamental note of the pipe it had to be blown gently, and on the whole the whistle proved the most efficient in piercing the fog.

An extraordinary amount of sound filled the air during these experiments. The resonant roar of the Bayswater and Knightsbridge roads; the clangor of the great bell of Westminster; the railway-whistles, which were frequently blown, and the fog-signals exploded at the various metropolitan stations, were all heard with extraordinary intensity. This could by no means be reconciled with the statements so categorically made regarding the acoustic impenetrability of a London fog.

On the 11th of December, the fog being denser than before, I heard every blast of the whistle, and occasional blasts of the pipe, over the distance between the bridge and the eastern end of the Serpentine. On joining my assistant at the bridge, the loud concussion of a gun was heard by both of us. A police-inspector affirmed that it came from Woolwich, and that he had heard several shots about 2 P. M. and previously. The fact, if a fact, was of the highest importance; so I immediately telegraphed to Woolwich for information. Prof. Abel kindly furnished me with the following particulars:

"The firing took place at 1.40 P. M. The guns proved were of comparatively small size—64-pounders, with 10-lb. charges of powder.

"The concussion experienced at my house and office, about three-quarters of a mile from the butt, was decidedly more severe than that experienced when the heaviest guns are proved with charges of 110 to 120 lbs. of powder. There was a dense fog here at the time of firing."

These were the reports heard by the police-inspector; on subsequent inquiry it was ascertained that two guns were fired at about 3 P. M. These were the guns heard by myself.

Prof. Abel also communicated to me the following fact:

"Our workman's bell at the arsenal-gate, which is of moderate size and any thing but clear in tone, is pretty distinctly heard by Prof. Bloxam *only* when the wind is *northeast.* During the whole of last week the bell was heard with great distinctness, the wind being *southwesterly* (opposed to the sound). The distance of the bell from Bloxam's house is about three-quarters of a mile as the crow flies."

Assuredly no question of science ever stood so much in need of revision as this of the transmission of sound through the atmosphere. Slowly but surely we mastered the question; and the further we advanced the more plainly it appeared that our reputed knowledge regarding it was erroneous from beginning to end.

On the morning of the 12th the fog attained its maximum density. It was not possible to read at my window, which fronted the open western sky. At 10.30 I sent an assistant to the bridge, and listened for his whistle and pipe at the eastern end of the Serpentine. The whistle rose to a shrillness far surpassing any thing previously heard, but it sank sometimes almost to inaudibility; proving that, though the air was on the whole highly homogeneous, acoustic clouds still drifted through the fog. A second pipe, which was quite inaudible yesterday, was plainly heard this morning. We were able to discourse across the Serpentine to-day with much greater ease than yesterday.

During our summer observations, I had once or twice been able to fix the position of the Foreland in thick haze by the direction of the sound. To-day my assistant, hidden by the fog, walked up to the Watermen's Boat-House sounding his whistle; and I walked along the opposite side of the Serpentine, clearly appreciating for a time that the line joining us was oblique to the axis of the river. Coming to a point which seemed to be exactly abreast of him, I marked it, and on the following day, when the fog had cleared away, the marked position was found to be perfectly exact. When undisturbed by echoes, the ear, with a little practice, becomes capable of fixing with great precision the direction of a sound.

On reaching the Serpentine this morning, a peal of bells, which then began to ring, seemed so close at hand that it required some reflection to convince me that they were ringing to the north of Hyde Park. The sounds fluctuated wonderfully in power. Prior to the striking of eleven by the great bell of Westminster, a nearer bell struck with loud clangor. The first five strokes of the Westminster bell were afterward heard, one of them being extremely loud; but the last six strokes were inaudible. An assistant was stationed to attend to the twelve-o'clock bells. The clock which had struck so loudly at eleven was unheard at twelve, while of the Westminster bell eight strokes out of twelve were inaudible. To such astonishing changes is the atmosphere liable.

At 7 P.M. the Westminster bell striking seven was not at all heard from the Serpentine, while the nearer bell already alluded to was heard distinctly. The fog had cleared away, and the lamps on the bridge could be seen from the eastern end of the Serpentine burning brightly; but, instead of the sound sharing the improvement of the light, what might be properly called an acoustic fog took the place of its optical predecessor. Several series of the whistle and organ-pipe were sounded in succession; one series only of the whistle-sounds was heard, all the others being quite inaudible. Three series of the organ-pipe were heard, but exceedingly faintly. On reversing the positions and sounding as before, nothing whatever was heard.

At eight o'clock the chimes and hour-bell of the Westminster clock were both very loud. The "acoustic fog" had shifted its position or temporarily melted away.

Extraordinary fluctuations were also observed in the case of the church-bells heard in the morning; in a few seconds they would sink from a loudly-ringing peal into utter silence, from which they would rapidly return to loud-tongued audibility. The intermittent drifting of fog over the sun's disk, by which his light is at times obscured, at times revealed, is the optical analogue of these effects. As regards such changes, the acoustic deportment of the atmosphere is a true transcript of its optical deportment.

At 9 P. M. three strokes only of the Westminster clock were heard; the others were inaudible. The air had relapsed in part into its condition at 7 P. M., when all the strokes were heard.

The quiet of the park this evening, as contrasted with the resonant roar which filled the air on the two preceding days, was very remarkable. The sound, in fact, was stifled in the optically clear but acoustically flocculent atmosphere.

On the 13th the fog being displaced by thin haze, I went again to the Serpentine. The carriage-sounds were damped to an extraordinary degree. The roar of the Knightsbridge and Bayswater roads had subsided, the tread of troops which passed us a little way off was unheard, while at 11 A. M. both the chimes and the hour-bell of the Westminster clock were stifled. Subjectively considered, all was favorable to auditory impressions; but the very cause that damped the local noises extinguished our experimental sounds. The voice across the Serpentine to-day, with my assistant plainly visible in front of me, was distinctly feebler than it had been when each of us was hidden from the other in the densest fog.

Placing the source of sound at the eastern end of the Serpentine, I walked along its edge from the bridge toward the end. The distance between these two points is about 1,000 paces. After five hundred of them had been stepped, the sound was not so distinct as it had been at the bridge on the day of densest fog; hence, by the law of inverse squares, the optical cleansing of the air through the melting away of the fog had so darkened it acoustically, that a sound generated at the eastern end of the Serpentine was lowered to one-fourth of its intensity at a point midway between the end and the bridge.

To these demonstrative observations one or two subsequent ones may be added. On several of the moist and warm days at the beginning of this year I stood at noon beside the railing of St. James's Park, near Buckingham Palace, three-quarters of a mile from the clock-tower, which was clearly visible. Not a single stroke of "Big Ben" was heard. On January 19th, fog and drizzling rain obscured the tower; still from the same position I not only heard the strokes of the great bell, but also the chimes of the quarter-bells.

During the exceedingly dense and "dripping" fog of January 22d, from the same railings, I heard every stroke of the bell. At the end of the Serpentine, when the fog was densest, the Westminster bell was heard striking loudly eleven. Toward evening this fog began to melt away, and at six o'clock I went to the end of the Serpentine to observe the effect of the optical clearing upon the sound. Not one of the strokes reached me. At nine o'clock and at ten o'clock my assistant was in the same position, and on both occasions he failed to hear a single stroke of the bell. It was a case precisely similar to that of December 13th, when the dissolution of the fog was accompanied by a decided acoustic thickening of the air.[1]

Observations at the South Foreland.—Satisfactory and indeed conclusive as these results seemed, I desired exceedingly to confirm them by experiments with the instruments actually employed at the South Foreland. On the 10th of February I had the gratification of receiving the following note and inclosure from the deputy-master of Trinity House:

"My dear Tyndall: The inclosed will show how accurately your views have been verified, and I send them on at once without waiting for the details. I think you will be glad to have them, and as soon as I get the report it shall be sent to you. I made up my mind ten days ago that there would be a chance in the light foggy-disposed weather at home, and therefore sent the Argus off at an hour's notice, and requested the Fog Committee to keep one member on board. On Friday I was so satisfied that the fog would occur that I sent Edwards down to record the observations. . . .

"Very truly yours, Fred. Arrow."

The inclosure referred to was notes from Captain Atkins and Mr. Edwards. Captain Atkins writes thus:

"As arranged, I came down here by the mail express, meeting Mr. Edwards at Cannon Street. We put up at the Dover Castle, and next morning at seven I was awoke by the sounds of the siren. On jumping up I discovered that the long-looked-for fog had arrived, and that the Argus had left her moorings.

"However, had I been on board, the instructions I left with Troughton (the master of the Argus) could not have been better carried out. About noon the fog cleared up and the Argus returned to her moorings, when I learned that they had taken both siren and horn sounds to a distance of 11 miles from the station, where they dropped a buoy. This I know to be correct, as I have this morning recovered the buoy, and the distances both in and out agree with Troughton's statement. I have also been to the Varne light-ship (12¾ miles from the Foreland), and ascertained that during the fog of Saturday forenoon they 'distinctly' heard the sounds."

Mr. Edwards, who was constantly at my side during our summer and autumn observations, and who is thoroughly competent to form a comparative estimate of the strength of the sounds, states that the sounds were "extraordinarily loud," both Captain Atkins and himself

[1] A friend informs me that he has followed a pack of hounds on a clear, calm day without hearing a single yelp from the dogs; while on calm, foggy days from the same distance the musical roar of the pack was loudly audible.

being awoke by them. He does not remember ever before hearing the sounds so loud in Dover; it seemed as though the observers were close to the instruments.

Other days of fog preceded this one, and they were all days of acoustic transparency, the day of densest fog being acoustically the clearest of all.

The results here recorded are of the highest importance, for they bring us face to face with a dense fog and an actual fog-signal, and confirm in the most conclusive manner the previous observations. The fact of Captain Atkins and Mr. Edwards being awakened by the siren proves, beyond all our previous experience, its power during the fog on the 7th of February.

It is exceedingly interesting to compare the transmission of sound on February 7th with its transmission on October 14th. The wind on both days had the same strength and direction. My notes of the observations show the latter to have been throughout a day of extreme optical clearness. The range was 10 miles. During the fog of February 7th, the Argus heard the sound at 11 miles; and it was also heard at the Varne light-vessel, which is 12¾ miles from the Foreland.

It is also worthy of note that through the same fog the sounds were well heard at the South Sand Head light-vessel, which is in the opposite direction from the South Foreland, and actually behind the siren. For this important circumstance is to be borne in mind: on February 7th the siren happened to be pointed, not toward the Argus, but toward Dover. Had the yacht been in the axis of the instrument, it is highly probable that the sound would have been heard all the way across to the coast of France.

It is hardly necessary for me to say a word to guard myself against the misconception that I consider sound to be assisted by the fog itself. The fog-particles have no more influence upon the waves of sound than the suspended particles stirred up over the banks of Newfoundland have upon the waves of the Atlantic. A homogeneous air is the usual associate of fog, and hence the acoustic clearness of foggy weather.

Experiments on Artificial Fogs.—These observations are clinched and finished by being brought within the range of laboratory experiment. Here we shall learn incidentally a lesson as to the caution required from an experimenter.

The smoke from smouldering brown paper was allowed to stream upward into the tunnel *a b c d* (*see* p. 689); the action upon the sound-waves was strong, rendering the short and agitated sensitive flame *k* tall and quiescent. Here the action of the smoke seemed clearly demonstrated.

Air, first passed through ammonia, then through hydrochloric acid, and thus loaded with thick fumes, was sent into the tunnel; the agitated flame was rendered immediately quiescent, indicating a very decided action on the part of the artificial fog.

Air passed through perchloride of tin and sent into the tunnel produced exceedingly dense fumes. The action of the fog upon the sound-waves was very strong.

The dense smoke of resin, burnt before the open end of the tunnel and blown into it with a pair of bellows, had also the effect of stopping the sound-waves, so as to still the agitated flame.

The result seems clear; and it perfectly harmonizes with the prevalent *a priori* notions as to the action of fog upon sound. But caution is here necessary; for the smoke of the brown paper was *hot;* the flask containing the hydrochloric acid was *hot;* that containing the perchloride of tin was *hot;* while the resin-fumes produced by a red-hot poker were also obviously hot. Were the results, then, due to the fumes or to the differences of temperature? The observations might well have proved a trap to an incautious reasoner.

Instead of the smoke and heated air, the heated air alone from four red-hot pokers was permitted to stream upward into the tunnel; the action on the sound-waves was very decided, though the tunnel was optically empty. The flame of a candle was placed at the tunnel-end, and the hot air just above its tip was blown into the tunnel; the action on the sensitive flame was decided. A similar effect was produced when the air, ascending from a red-hot iron, was blown into the tunnel.

In these latter cases the tunnel remained optically clear, while the same effect as that produced by the resin—smoke and fumes—was observed. Clearly, then, we are not entitled to ascribe, without further investigation, to the artificial fog an effect which may have been due to the air which accompanied it.

Having eliminated the fog and proved the non-homogeneous air effective, our reasoning will be completed by eliminating the heat, and proving the fog ineffective.

Instead of the tunnel *a b c d* (*see* p. 689), a cupboard with glass sides, three feet long, two feet wide, and about five feet high, was filled with fumes of various kinds. Here it was thought the fumes might remain long enough for differences of temperature to disappear. Two apertures were made in two opposite panes of glass three feet asunder; in front of one aperture was placed the bell in its padded box and behind the other aperture, and at some distance from it, the sensitive flame.

Phosphorus placed in a cup floating on water was ignited within the closed cupboard. The fumes were so dense that considerably less than the three feet traversed by the sound extinguished totally a bright candle-flame. At first there was a slight action upon the sound; but this rapidly vanished, the flame being affected exactly as if the sound passed through pure air. The first action was manifestly due to differences of temperature, and disappeared when the temperature was equalized.

The cupboard was next filled with the dense fumes of gunpowder. At first there was a slight action; but this disappeared even more rapidly than in the case of the phosphorus, the sound passing as if no fumes were there. It required less than half a minute to abolish the action in the case of the phosphorus, but a few seconds sufficed in the case of the gunpowder. The fumes were far more than sufficient to quench the candle-flame.

The dense smoke of resin, when the temperature had become equable, exerted no action on the sound.

The fumes of gum-mastic were equally ineffectual.

The fumes of the perchloride of tin, though of extraordinary density, exerted no sensible effect upon the sound.

Exceedingly dense fumes of chloride of ammonium next filled the cupboard. A fraction of the length of the three-foot tube sufficed to quench the candle-flame. Soon after the cupboard was filled, the sound passed without the least sensible deterioration. An aperture at the top of the cupboard was opened; but, though a dense smoke-column ascended through it, many minutes elapsed before the candle-flame could be seen through the attenuated fog.

Steam from a copper boiler was so copiously admitted into the cupboard as to fill it with a dense cloud. No real cloud was ever so dense; still the sound passed through it without the least sensible diminution. This being the case, cloud-echoes are not a likely phenomenon.

In all of these cases, when a couple of Bunsen's burners were ignited within the cupboard containing the fumes, less than a minute's action rendered the air so heterogeneous that the sensitive flame was completely stilled.

These acoustically inactive fogs were subsequently proved competent to cut off the electric light.

Experiment and observation go, therefore, hand-in-hand in demonstrating that fogs have no sensible action upon sound; the notion of their impenetrability which so powerfully retarded the introduction of phonic coast-signals being thus abolished, we have solid ground for the hope that disasters due to fogs and thick weather will, in the future, be materially mitigated.

Action of Wind.—In stormy weather we were frequently forsaken by our steamer, which had to seek shelter in the Downs or Margate Roads, and on such occasions the opportunity was turned to account to determine the effect of the wind. On October 11th, accompanied by Mr. Douglas and Mr. Edwards, I walked along the cliffs to Dover Castle toward the Foreland, the wind blowing strongly against the sound. On the Dover side, and at about a mile and a half from the Foreland, we first heard the faint but distinct sound of the siren. The horn-sound was inaudible. A gun fired during our halt was also unheard.

As we approached the Foreland we saw the smoke of the gun. Mr. Edwards heard a faint crack, but neither Mr. Douglas nor I heard any thing. The sound of the siren was, at the same time, of piercing intensity. We waited for ten minutes, when another gun was fired. The smoke was at hand, and I thought I heard a faint thud, but could not be certain. My companions heard nothing. On pacing the distance afterward, we were found to be only 550 yards from the gun. We were shaded at the time by a slight eminence from both the siren and the gun, but this could not account for the utter extinction of the gun-sound at so short a distance, and at a time when the siren sent to us a note of great power.

Mr. Ayres, at my request, walked to windward along the cliff, while Mr. Douglas proceeded to St. Margaret's Bay. During their absence I had three guns fired. Mr. Ayres heard only one of them. Favored by the wind, Mr. Douglas, at twice the distance, and far more deeply immersed in the sound-shadow, heard all three reports with the utmost distinctness.

Joining Mr. Douglas, we continued our walk to a distance of three-quarters of a mile beyond St. Margaret's Bay. Here, being dead to leeward, though the wind blew with unabated violence, the sound of the siren was borne to us with extraordinary power.[1] In this position we also heard the gun loudly, and two other loud reports at the proper interval of ten minutes, as we returned to the Foreland.

It is within the mark to say that the gun to-day was heard five times, and might have been heard fifteen times as far to leeward as to windward.

In windy weather the shortness of its sound is a serious drawback to the use of a gun as a signal. In the case of the horn and siren, time is given for the attention to be fixed upon the sound; and a single puff, while cutting out a portion of the blast, does not obliterate it wholly. Such a puff, however, may be fatal to the momentary gun-sound.

On the leeward side of the Foreland, on the 23d, the sounds were heard at least four times as far as on the windward side, while in both directions the siren possessed the greatest penetrative power.

On the 24th the wind shifted to east-southeast, and the sounds, which, when the wind was west-southwest, failed to reach Dover, were now heard in the streets through thick rain. On the 27th the wind was east-northeast. In our writing-room, in the Lord Warden Hotel, in the bedrooms, and on the staircase, the sound of the siren reached

[1] The horn here was temporarily suspended, but doubtless would have been well heard.

us with surprising power, piercing through the whistling and moaning of the wind, which blew through Dover toward Folkestone. The sounds were heard at 6 miles from the Foreland on the Folkestone road, and, had the instruments not then ceased sounding, they might have been heard much farther. At the South Sand Head light-vessel, 3¾ miles on the opposite side, no sound had been heard throughout the day. On the 28th, the wind being north by east, the sounds were heard in the middle of Folkestone, 8 miles off, while in the opposite direction they failed to reach 3¾ miles. On the 29th the limits of range were Eastware Bay on the one side, and Kingsdown on the other; on the 30th the limits were Kingsdown on the one hand, and Folkestone Pier on the other. With a wind having a force of 4 or 5, it was a very common observation to hear the sound in one direction three times as far as in the other.

This well-known effect of the wind is exceedingly difficult to explain. Indeed, the only explanation worthy of the name is one offered by Prof. Stokes, and suggested by some remarkable observations by De la Roche. In vol. i. of the "Annales de Chemie" for 1816, p. 176, Arago introduces De la Roche's memoir in these words: "L'auteur arrive à des conclusions, qui d'abord pourront paraître paradoxales, mais ceux qui savent combien il mettait de soins et d'exactitude dans toutes ses recherches se garderont sans doute d'opposer une opinion populaire à des expériences positives." The strangeness of De la Roche's results consisted in his establishing, by quantitative measurements, not only that sound has a greater range in the direction of the wind than in the opposite direction, but that the range at right angles to the wind is the maximum.

In a short but exceedingly able communication presented to the British Association in 1857, the eminent physicist above-mentioned points out a cause which, *if sufficient*, would account for the results referred to. The lower atmospheric strata are retarded by friction against the earth, and the upper ones by those immediately below them; the velocity of translation, therefore, in the case of wind, increases from the ground upward. This difference of velocity tilts the sound-wave upward in a direction opposed to, and downward in a direction coincident with, the wind. In this latter case the direct wave is reënforced by the wave reflected from the earth. Now, the reënforcement is greatest in the direction in which the direct and reflected waves inclose the smallest angle, and this is at right angles to the direction of the wind. Hence the greater range in this direction. It is not, therefore, according to Prof. Stokes, a stifling of the sound to windward, but a tilting of the sound-wave over the heads of the observers that defeats the propagation in that direction.

This explanation calls for verification, and I wished much to test it by means of a captive balloon rising high enough to catch the deflected wave; but, on communicating with Mr. Coxwell, who has earned for himself so high a reputation as an aëronaut, and who has always shown himself so willing to promote a scientific object, I learned with regret that the experiment was too dangerous to be carried out.[1]

Atmospheric Selection.—It has been stated that the atmosphere on different days shows preferences to different sounds. This point is worthy of further illustration.

After the violent shower which passed over us on October 18th, the sounds of all the instruments, as already stated, rose in power; but it was noticed that the horn-sound, which was of lower pitch than that of the siren, improved most, at times not only equaling but surpassing the sound of its rival. From this it might be inferred that the atmospheric change produced by the rain favored more especially the transmission of the longer sonorous waves.

But our programme enabled us to go further than mere inference. It had been arranged on the day mentioned, that up to 3.30 p. m. the siren should perform 2,400 revolutions a minute, generating 480 waves a second. As long as this rate continued, the horn, after the shower, had the advantage. The rate of rotation was then changed to 2,000 a minute, or 400 waves a second, when the siren-sound immediately surpassed that of the horn. A clear connection was thus established between aërial reflection and the length of the sonorous waves.

The 10-inch Canadian whistle being capable of adjustment so as to produce sounds of different pitch, on the 10th of October I ran through a series of its sounds. The shrillest appeared to possess great intensity and penetrative power. The belief is common that a note of this character (which affects so powerfully, and even painfully, an observer close at hand) has also the greatest range. Mr. A. Gordon, in his examination before the Committee on Light-houses, in 1854, expressed himself thus: "When you get a shrill sound, high in the scale, that sound is carried much farther than a lower note in the scale." I have heard the same opinion expressed by other scientific men.

On the 14th of October the point was submitted to an experimental test. It had been arranged that up to 11.30 a. m. the Canadian whistle, which had been heard with such piercing intensity on the 10th, should sound its shrill note. At the hour just mentioned we were beside the Varne buoy, 7¾ miles from the Foreland. The siren, as we approached the buoy, was heard through the paddle-noises; the horns were also heard, but more feebly than the siren. We paused at the buoy and listened for the 11.30 gun. Its boom was heard by all. Neither before nor during the pause was the shrill-sounding Canadian whistle once heard. It was now adjusted to produce its ordinary low-pitched note, which was immediately heard. Still farther

[1] Experiments so important as those of De la Roche ought not to be left without verification. I have made arrangements with a view to this object.

out the low boom of the cannon continued audible after all the other sounds had ceased.

But it was only during the early part of the day that this preference for the longer waves was manifested. At 3 P. M. the case was completely altered, for then the high-pitched siren was heard when all the other sounds were inaudible. On many other days we had illustrations of the varying comparative power of the siren and the gun. On the 9th of October, sometimes the one, sometimes the other was predominant. On the morning of the 13th the siren was clearly heard on Shakespeare's Cliff, while two guns, with their puffs perfectly visible, were unheard. On October 16th, two miles from the signal-station, the gun at eleven o'clock was inferior to the siren, but both were heard. At 12.30, the distance being 6 miles, the gun was quite unheard, while the siren continued faintly audible. Later on in the day the experiment was twice repeated. The puff of the gun was in each case seen, but nothing was heard; in the last experiment, when the gun was quenched, the siren sent forth a sound so strong as to maintain itself through the paddle-noises. The day was clearly hostile to the passage of the longer sonorous waves.

October 17th began with a preference for the shorter waves. At 11.30 A. M. the mastery of the siren over the gun was pronounced; at 12.30 the gun slightly surpassed the siren; at 1, 2, and 2.30 P. M. the gun also asserted its mastery. This preference for the longer waves was continued on October 18th. On October 20th the day began in favor of the gun, then both became equal, and finally the siren gained the mastery; but the day had become stormy, and a storm is always unfavorable to the momentary gun-sound. The same remark applies to the experiments of October 21st. At 11 A. M., distance $6\frac{1}{2}$ miles, when the siren made itself heard through the noises of wind, sea, and paddles, the gun was fired; but, though listened for with all attention, no sound was heard. Half an hour later the result was the same. On October 24th five observers saw the flash of the gun at a distance of 5 miles, but heard nothing; all of them at this distance heard the siren distinctly; a second experiment on the same day yielded the same result. On the 27th also the siren was triumphant; and on three several occasions on the 29th its mastery over the gun was very pronounced.

Such experiments yield new conceptions as to the scattering of sound in the atmosphere. No sound here employed is a simple sound; in every case the fundamental note is accompanied by others, and the action of the atmosphere on these different groups of waves has its optical analogue in that scattering of the waves of the luminiferous ether which produces the various shades and colors of the sky.

CONCLUDING REMARKS.—A few additional remarks and suggestions will fitly wind up this paper. It has been proved that in some states of the weather the howitzer firing a 3-lb. charge commands a larger range than the whistles, trumpets, or siren. This was the case, for example, on the particular day, October 17th, when the ranges of all the sounds reached their maximum.

On many other days, however, the inferiority of the gun to the siren was demonstrated in the clearest manner. The gun-puffs were seen with the utmost distinctness at the Foreland, but no sound was heard, the note of the siren at the same time reaching us with distinct and considerable power.

The disadvantages of the gun are these:

a. The duration of the sound is so short that, unless the observer is prepared beforehand, the sound, through lack of attention rather than through its own powerlessness, is liable to be unheard.

b. Its liability to be quenched by a local sound is so great, that it is sometimes obliterated by a puff of wind taking possession of the ears at the time of its arrival. This point was alluded to by Arago, in his report on the celebrated experiments of 1822. By such a puff a momentary gap is produced in the case of a continuous sound, but not entire extinction.

c. Its liability to be quenched or deflected by an opposing wind, so as to be practically useless at a very short distance to windward, is very remarkable. A case has been cited in which the gun failed to be heard against a violent wind at a distance of 550 yards from the place of firing, the sound of the siren at the same time reaching us with great intensity.

Still, notwithstanding these drawbacks, I think the gun is entitled to rank as a first-class signal. I have had occasion myself to observe its extreme utility at Holyhead and the Kish light-vessel near Kingstown. The commanders of the Holyhead boats, moreover, are unanimous in their commendation of the gun. An important addition in its favor is the fact that in fog the flash or glare often comes to the aid of the sound; on this point the evidence is quite conclusive.

There may be cases in which the combination of the gun with one of the other signals may be desirable. Where it is wished to confer an unmistakable individuality on a fog-signal station, such a combination might with advantage be resorted to.

If the gun be retained as one form of fog-signal (and I should be sorry at present to recommend its total abolition), it ought to be of the most suitable description. Our experiments prove the sound of the gun to be dependent on its shape; but we do not know that we have employed the best shape. This suggests the desirability of constructing a gun with special reference to the production of sound.[1]

An absolutely uniform superiority on all days cannot be conceded to any one of the instruments subjected to examination; still, our observa-

[1] The Elder Brethren have already had plans of a new signal-gun laid before them by the constructors of the War Department.

tions have been so numerous and long-continued as to enable us to come to the sure conclusion that, on the whole, the steam-siren is the most powerful fog-signal which has hitherto been tried in England. It is specially powerful when local noises, such as those of wind, rigging, breaking waves, shore-surf, and the rattle of pebbles, have to be overcome. Its density, quality, pitch, and penetration, render it dominant over such noises after all other signal-sounds have succumbed.

I have not, therefore, hesitated to recommend the introduction of the siren as a coast-signal.

It will be desirable in each case to confer upon the instrument a power of rotation, so as to enable the person in charge of it to point its trumpet against the wind or in any other required direction. This arrangement was made at the South Foreland, and it presents no mechanical difficulty. It is also desirable to mount the siren so as to permit of the depression of its trumpet fifteen or twenty degrees below the horizon.

In selecting the position at which a fog-signal is to be mounted, the possible influence of a sound-shadow, and the possible extinction of the sound by the interference of the direct waves with waves reflected from the shore, must form the subject of the gravest consideration. Preliminary trials may, in most cases, be necessary before fixing on the precise point at which the instrument is to be placed.

The siren, it will be remembered, has been hitherto worked with steam of 70 lbs. pressure or thereabouts; the trumpets have been worked with compressed air; and our experiments have proved that a pressure of 20 lbs. yielded sensibly as loud a sound as higher pressures. The possibility of obtaining a serviceable sound with this low air-pressure may render available the employment of caloric engines with trumpets; if so, the establishment of trumpets on board light-vessels would be greatly facilitated. The signals at present existing on board such vessels are exceedingly defective, and may be immeasurably improved upon. There are, I am told, practical difficulties as to the introduction of steam on board light-ships; otherwise I should be strongly inclined to recommend the introduction among them of the Canadian whistle. The siren would probably be found too large and cumbrous for light-vessels.

The siren, which has been long known to scientific men, is worked with air, and it would be worth while to try how the fog-siren would behave supposing compressed air to be substituted for steam. Compressed air might also be tried with the whistles.

No fog-signal hitherto tried is able to fulfill the condition laid down in a very able letter already referred to, namely, that "*all fog-signals should be distinctly audible for at least* 4 *miles, under every circumstance.*" Circumstances may exist to prevent the most powerful sound from being heard at half this distance. What may with certainty be affirmed is, that in almost all cases the siren may certainly be relied on at a distance of 2 miles; in the great majority of cases it may be relied upon at a distance of 3 miles, and in the majority of cases to a distance greater than 3 miles.

Happily the experiments thus far made are perfectly concurrent in indicating that at the particular time when fog-signals are needed, the air, holding the fog in suspension, is in a highly-homogeneous condition; hence it is in the highest degree probable that in the case of fog we may rely upon the signals being effective at far greater distances than those just mentioned.

I am cautious not to inspire the mariner with a confidence which may prove delusive. When he hears a fog-signal he ought, as a general rule (at all events until extended experience justifies the contrary), to assume the source of sound to be not more than 2 or 3 miles distant, and to heave his lead or take other necessary precautions. If he errs at all in his estimate of distance, it ought to be on the side of safety.

With the instruments now at our disposal wisely established along coasts, I venture to think that the saving of property in ten years will be an exceedingly large multiple of the outlay necessary for the establishment of such signals. The saving of life appeals to the higher motives of humanity.

In a report written for the Trinity House on the subject of fog-signals, my excellent predecessor, Prof. Faraday, expresses the opinion that a false promise to the mariner would be worse than no promise at all. Casting our eyes back upon the observations here recorded, we find the sound-range on clear, calm days varying from 2½ miles to 16½ miles. It must be evident that an instruction founded on the latter observation would be fraught with peril in weather corresponding to the former. Not the maximum but the minimum sound-range should be impressed upon the mariner. Want of attention to this point may be followed by disastrous consequences.

This remark is not made without cause. I have before me a "Notice to Mariners," issued by the Board of Trade, regarding a fog-whistle recently mounted at Cape Race, and which is reputed to have a range of 20 miles in calm weather, 30 miles with the wind; and in stormy weather or against the wind 7 to 10 miles. Now, considering the distance reached by sound in our observations, I should be willing to concede the possibility, in a more homogeneous atmosphere than ours, of a sound-range on *some* calm days of 20 miles, and on *some* light, windy days of 30 miles, to a powerful whistle; but I entertain a strong belief that the stating of these distances, or of the distance 7 to 10 miles against a storm, without any qualification, is calculated to inspire the mariner with false confidence. I would venture to affirm that at Cape Race calm days might be found in which the range of the sound will be less than one-fourth of what this notice states it to be.

Such publications ought to be without a trace of exaggeration, and furnish only data on which the mariner may with perfect confidence rely. My object in extending these observations over so long a period was to make evident to all how fallacious it would be, and how mischievous it might be, to draw general conclusions from observations made in weather of great acoustic transparency.

Thus ends, for the present at all events, an inquiry which I trust will prove of some importance, scientific as well as practical. In conducting it I have had to congratulate myself on the unfailing aid and coöperation of the Elder Brethren of the Trinity House. Captain Drew, Captain Close, Captain Were, Captain Atkins, and the deputy-master, have all, from time to time, taken part in the inquiry. To the eminent arctic navigator, Admiral Collinson, who showed throughout unflagging, and, I would add, philosophic interest in the investigation, I am indebted for most important practical aid; he was almost always at my side, comparing opinions with me, placing the steamer in the required positions, and making, with consummate skill and promptness, the necessary sextant observations. I am also deeply sensible of the important services rendered by Mr. Douglas, the able and indefatigable engineer; of Mr. Ayres, the assistant engineer; and of Mr. Price Edwards, the private secretary of the deputy-master of the Trinity House.

The officers and gunners at the South Foreland also merit my best thanks, as also Mr. Holmes and Mr. Laidlaw, who had charge of the trumpets, whistles, and siren.

In the subsequent experimental treatment of the subject I have been most ably aided by my excellent assistant, Mr. John Cottrell.

APOPLEXY.

BY J. R. BLACK, M.D.

IF there is any one disease that the diligent brain-worker, a little past middle life, has reason to fear, it is apoplexy. Although statistical evidence is wanting, the experience of the physician confirms the popular belief that more of our distinguished men are carried off by this disease, or by one of its sequels, paralysis, than by any other cause. The influences which tend to produce such a result, and the best means of avoiding them, are the objects we propose briefly to discuss.

A middle-aged physician said one day to the writer: "As I was walking down the street after dinner I felt a shock in the back of my head, as if some one had struck me; I have not felt well since. I fear I shall die, just as all my ancestors have, of paralysis. What shall I do?" The answer was, "Diminish the tension on the blood-vessels, and there need be no fear of tearing them in a weak place." Now, this expresses in plain terms the exact cause of apoplexy in the great majority of instances; and it is one, too, which every one has it in his power to prevent. A blood-vessel of the brain, from causes which will presently be mentioned, has lost some of its elastic strength; food is abundant, digestion is good; blood is made in abundance, but little is worked off by exercise; the tension on every artery and vein is at a maximum rate; the even, circuitous flow is temporarily impeded at some point, throwing a dangerous pressure on another; the vessel which has lost its elastic strength gives way, blood is poured out, a clot is formed, which, by its pressure on the brain, produces complete unconsciousness. This is the apoplectic stroke. It will be perceived that there are two leading conditions upon which the production of the stroke depends: a lessened strength in the vessel, and an increased tension on it.

There are no vessels carrying blood to and from the various organs of the body which so frequently rupture as those in the brain. The causes that produce this result are the fatty degeneracy of the middle arterial coat of the cerebral vessels, whereby their elastic strength is much impaired, the great irregularity of blood distribution to the contents of the cranium, and the little support which the pulpy substance of the brain gives to the weakened vessels embedded in it.

The forms of degeneracy that are found in the arteries of the brain are the fatty and the calcareous. The microscope has made some startling revelations on this fatty decay. The strong, elastic fibres, that should make up the substance of the middle arterial coat, are, in places here and there, no longer to be seen, their place being occupied by fatty globules, which have very little resisting power to a disturbing force.

The chief causes which produce this structural change are the habitual use of ardent spirits and tobacco. Every one is aware that the leading effects of these agents on the body are such as show that the functions of the nervous system are more affected than any other; and the physician also knows that, when symptoms of disorder arise from their use, they are such as denote that the nervous system is almost alone implicated. Delirium tremens, insomnia, tremulous hands, and nervous headaches, are some of the characteristic effects of the habitual use of stimulants and narcotics.

Ardent spirits also tend to produce an over-fullness of the cerebral vessels, and to affect the functions of the brain in a manner which strangely blends stupidity, brightness, and exhilaration. Effects so unnatural, and so frequently ending in disease, influence injuriously the nutrition of the nervous centres. And to interfere with the nutrition of any part of the body is simply to impair the life and power of its structure. The evidences of this impairment may not be felt immediately. In fact, the evidences of impairment by any bad habit are seldom apparent during the prime of youthful vigor. But the mischief is going on nevertheless, and the organ upon which the weight of infringement falls will be the one that will first manifest signs of disease, and through which death will make its conquest over the body.

Besides this weakening of the vessels upon which the strong impulse of blood from the heart falls at the rate of sixty times a minute, and the very little external support such defective vessels receive from the soft and pulpy brain, there is another source of danger by a break, in the extraordinary ebbs and tides of blood to which the contents of the cranium are subject. During sleep the brain is almost bloodless; its substance seems to shrink into a lifeless mass; but the moment that wakefulness occurs it swells out, gets red, its arteries and veins becoming distended with a great tide of blood. No other part of the body is subject to such droughts and floods in its blood-circulation. This inequality is yet further increased by severe mind-labor. The ardent student is well aware that deep thought heats the head and cools the feet. The brain is then receiving more than an ordinary supply of blood and the feet less.

The first apoplectic stroke, as a rule, is not a severe one. Sometimes the condition of the cerebral circulation is simply that of active congestion; but more commonly a little blood escapes by a tiny vent, the shock to the system slows and enfeebles the action of the heart, the distention of the ruptured vessel is thus lessened, the escape of blood ceases, and Nature, by means of a slight inflammation, heals the part torn, and in due time removes the blood-clot by absorption.

The process by which a weakened blood-vessel is ruptured by internal distention may be illustrated by observing the effect of attempting to force through an old water-hose attached to a fire-engine a large and rapid stream of water. The weakness of the hose is first shown by the escape of tiny jets of water; but by-and-by a larger vent occurs, allowing the water to escape in a flood. Just so it is with the progressive weakening with the blood-vessels in the brain—the escape of blood is at first small; then, under a greater tension than ordinary, a larger rent is made, allowing the blood to escape in hopeless profusion. It was probably these well-known features of apoplectic strokes that led the great Napoleon's medical adviser to make his celebrated reply in reference to this disease, of which the emperor stood in great dread: "Sire, the first attack is a warning, the second a summons, the third a summons to execution."

Those who have a family tendency to apoplexy and are desirous to escape it, will, of course, avoid all the causes above referred to, especially those which tend to destroy the elasticity and strength of the blood-channels in the brain, or, in other words, to weaken the structure and life of those parts. But suppose, as is too often the case, that the very sort of life has been led and the very habits indulged in which are most likely to produce a weakness and fragility in the coats of the vessels of the brain. What is to be done? *Clearly to diminish and keep the tension on these vessels by the blood at a low rate all the time.* As remarked at the commencement of this article, this is fully in our power by cutting off the supplies. A prudent fire-engineer, when his water-hose are old and weak, would not try to force as much water as he could into them. No; to prevent a rupture he would work them at a low pressure. But men seldom think of carrying out the same simple mechanical principle when there is reason to believe that the vessels of the brain are getting weak and brittle. They eat and drink just as much as they feel inclined to, and sometimes a little more. With a good digestion, nearly all they consume is converted into blood, to the yet further distention of vessels already over-distended. This high-pressure style of living produces high-pressure results. Its effects were painfully illustrated by the death of Charles Dickens. The brain-work he performed was immense; he lived generously, taking his wine as he did his meat, with a liberal hand. He disregarded the signs of structural decay, forcing his reluctant brain to do what it had once done with spontaneous ease, until all at once, under a greater tension than ordinary, a weak vessel gave way, flooding the brain with blood.

Medical writers on this disease all refer to the fact that a stroke of apoplexy quite frequently occurs just after eating a full meal. The experience of physicians also is that violent attacks of vertigo often attend a deranged or inactive condition of the liver. To explain in detail the causes of an unusual pressure of blood on the brain from certain states of the digestive organs would be somewhat tedious. Suffice it to say that it is produced by what may be termed a back-water action of an obstruction to the circulation of the blood, whereby distention occurs in one of the most distensible of the internal organs of the body, the brain. We have already stated that the distribution of blood to the brain is the most irregular in the body; that its blood-vessels are subject to be weakened by improper habits, and that the pulpy cerebral substance gives very little if any support to a weak vessel in it, so that all the conditions favorable to a rupture by a little more distention than ordinary very frequently coexist.

A not uncommon condition of the arteries of the brain, especially at its base, in those far advanced in years, is the displacement in places of the middle coat by lime-particles, which, of course, renders them easily torn. So far as known this condition is incurable, as well as unpreventable. It is one of the changes of structure incident to very old age. The only measure that can be relied upon to prevent a rupture under such conditions is to be cautious about distending them with blood. This is, in fact, the great fundamental principle of prevention when the vessels of the brain are weak from any cause.

To effect this, certain regulations in eating and drinking are far better preventives than any medicine, or even occasional bleedings. The latter method is particularly unsafe. After bleeding from the arm, new blood is often made more rapidly than under other circumstances, and so may become, before a person is well aware of it, very abundant, with a dangerous pressure on the weak vessels. The subject of such a practice is very apt to rely on the abstraction of blood for safety, and take no care otherwise of himself. Besides, he has no accurate means of knowing when the pressure of the blood is becoming dangerously great. The periodical bleeding from piles is a very different matter. They often act as a safety-valve to the high pressure from within, and regulate themselves on mechanical principles. Full-blooded persons, past middle life, and with a predisposition to apoplexy, should never try to remove such a safety-valve.

As soon as old age puts a decided check on the amount of daily exercise, it is time to put a decided check on the amount of food daily consumed. If the supply of new matter is greater than the waste of the old, an accumulation of surplus blood must be the result. The principle is an important one, yet it is little known and less practised. Men well past middle life, who do not exercise half as much as in their younger years, often eat as freely of highly-nutritious food as they ever did. Such a course is very dangerous. The tension on the vascular system must not be increased, but diminished, if the risk of an apoplectic stroke would be avoided.

The kind of food best adapted to keep down superfluous blood is the vegetable. Animal food makes blood with dangerous rapidity, nearly all its substance dissolving for this purpose in the stomach. Laboring-men, however, may eat of animal food in moderation, as the exercise of their muscles wastes their substance largely, requiring a good deal of blood to make up for the wear.

The amount of vegetable food should not be so great as in middle life. The true rule is, not to eat to entire satiety. Even those of younger years and sedentary habits will feel lighter and better in every way by leaving the table a little hungry.

All strong liquors are unsuited to those with an apoplectic tendency. One of their prominent effects, as we have seen, is to cause a degeneration in the coating of the blood-vessels, and another is to move more blood than ordinary upon the brain.

ON THE CORRECTNESS OF PHOTOGRAPHS.[1]

By Dr. HERMANN VOGEL,

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In the previous chapters we have become acquainted with the development and the theory and practice of photography, and have mentioned cursorily various of its applications. It is our present purpose to give special attention to one point which is of great import in judging of the value of a photograph.

Most persons have a fancy that the application of photography is always uniform, whatever may be the object to be taken, and, therefore, that a photographer who can take a portrait must be able to take equally well a machine, a landscape, or an oil-painting. This results from the erroneous notion that the picture makes itself when the photographer opens and shuts the lid. But our readers know already that the picture does not make itself, but that it must be first developed, brought out, fixed, and copied. In all these operations there is no precise measure or rule how long the photographer should expose to the light, develop, fortify, copy, and tone the picture. This depends on his option and judgment; and he is able at pleasure to bring out the picture more or less in detail, according to the time of exposure. Again, he can make it more or less brilliant, according to the degree of strengthening; he can make it more or less dark, according to the mode of imprinting; more or less blue, according as he tones it down. But what is it that directs his judgment to determine if the picture is correct or not? It is Nature, and Nature alone! He must know Nature, and compare it with his picture. Nor is this easy. Nature appears positive to him, but in the picture she appears first negative; and, if he compares the two, he must be able in his mind to convert the picture, that is, to change it and represent it as a positive, which it is afterward to become. More comparing and study is required to do this than is generally supposed.

If two printed proofs are presented to a man who is ignorant of the art of printing, one of the sheets in question being well and the other ill printed, if the defects be not too glaring, this person will not be able to detect any difference between the proofs. Far otherwise is it with the practised eye of the printer, who immediately detects that in one proof the type is too thick, or thin, or leaded, or that the letters are faint, or blotched, or uneven. In like manner, a practised eye is needed to judge a photograph—an eye not only able to detect the finest details of the picture, but also the peculiarities of the original. The unprofessional man often uses the expression, "I have no eye for

[1] Abridged from the "Chemistry of Light and Photography," No. XIV. of the "International Scientific Series."

it"—that is, "I am not accustomed to see such things"—and it is in this manner that we first discover how imperfectly we use this, the most perfect of our senses.

A man born blind, and who receives his sight by an operation, cannot at first distinguish a cube from a ball, or a cat from a dog. He is not accustomed to see such things, and must first exercise his eyes and learn to see.

We, also, though in possession of sound organs, are blind to all things that we are not accustomed to see; and this fact is most apparent in art, as also in photography, so closely related to it.

If photographers principally engaged in taking portraits are not able to produce a good landscape, the reason of this is that they have no eye for landscape—that they consider a picture to be good after too short an exposure, or when imperfectly developed and strengthened, or when inaccurately printed. It proceeds from their not knowing the influence exercised by the position and intensity of the sun on the aërial perspective produced by clouds, without speaking of other points of less importance.

Thus every class of subjects requires a special study, though the manipulation of photography remains in all cases the same; therefore, there are photographers whose proper province is portraits, and others devoted to landscapes, to the reproduction of oil-paintings, etc.

The remark is frequently made by admirers of photography, that this newly-invented art gives a perfectly truthful representation of objects, understanding by the term truthful a perfect agreement with reality. Photography can, in fact, when properly applied, produce truer pictures than all other arts; but it is not absolutely true. And, as it is not so, it is important to become acquainted with the sources of inaccuracy in photography. Many exist. I shall treat here especially of optical errors.

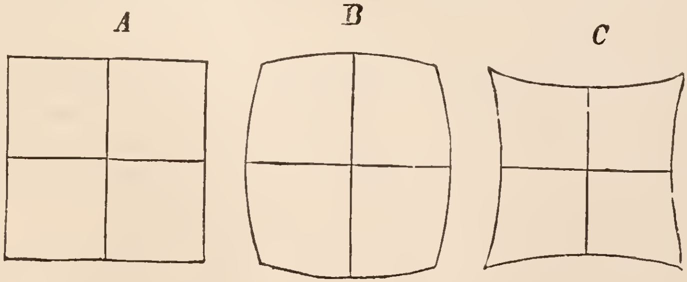


FIG. 1.

The lenses which are employed in photography do not always give absolutely true pictures. Suppose, for example, that a simple lens receives the impression of a square; it often represents it with curvilinear sides, as in the diagrams *A*, *B*, *C* (Fig. 1), though with a feebler outline. A picture thrown off quite out of drawing by such a lens, in which straight lines turn out as curves, is evidently inaccurate. The inaccuracy may not be felt by many, but it exists. It may perhaps be expected that this defect disappears in the case of what are called correct lenses, but let the attempt be made to obtain a view with these correct lenses of lofty buildings taken from a low position. The lines that ought to be perpendicular commonly converge upward. This is caused by the photographer being obliged to direct his instrument at an acute angle upward, in order to be able to take in a view of the whole building. In doing this, perpendicular lines project themselves, converging upward. To avoid this defect, lenses have been made with a very large field of view. These are called pantoscopes. But these reproduce distant objects apparently on a very

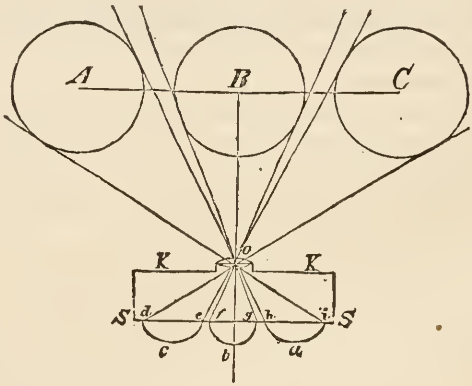


Fig. 2.

small scale, and objects near at hand on a very large scale—peculiarities unnoticed by unprofessional persons, but detected by close observers of Nature.

A remarkable phenomenon, exciting the wonder of the uninitiated, is the distortion of spheres in photography. Let the reader imagine a row of cannon-balls; these will always appear balls to us, and the artist will always draw them as a circle. But, if they are taken through a lens with a large field of view, the balls situated near the rim of the lens no longer appear circular, but elliptical.

To explain this phenomenon, we must attend once more to the mode in which the picture is produced. Let it be conceived that there are three balls, *A B C*, in front of a camera, *K*, with the lens *o* (Fig. 2). Each ball projects a cone of rays on the optical centre of the lens. This is continued within the camera, and cuts the surface of the picture, if its axis falls obliquely upon it, in the form of an ellipse, such as *A C*. Only, if the axis of the cone of rays is perpendicular to the surface of the picture *S S*, as at *B*, the picture appears a circle. I admit that this defect only occurs when the field of view of the lens is very large, and the balls are situated very near its rim.

A photographer brought to the author the picture of a castle having a row of statues in front of it, which he had taken with a lens having a large field of view. Singularly, the heads of the statues toward the margin became continually broader, and similarly their bodies; and the slim Apollo-Belvedere, who unfortunately stood on the very edge of the margin, had such full-blown cheeks and so protuberant a paunch that he looked like Dr. Luther.

But, quite independently of these considerations, there is another point that must materially affect the accuracy of photographic representation. Photography generally gives the light parts too light, and exaggerates the dark shadows. This is a fundamental error which is associated with their very nature, and which it is very difficult to avoid. It is seen in the most evident manner in taking objects lighted by a brilliant sun; for example, a statue. If the exposure is short, a detailed picture is obtained of the light side, but the shady side is a black daub or blotch. If the exposure is long, the shady side is full of detail, but the light side exposed too much, and so thickly covered that the details are wanting in it. Hence photographers are often driven to subterfuges if they wish to obtain a correct picture; they are obliged to mitigate the contrasts—to make the light more toned down, and the shades lighter than painters are wont to make them. The latter often exclaim when they see the photographic exposure of a model, and wonder if the picture will be correct. And no doubt, in the case of landscapes and architecture, the results are not always satisfactory.

The author once took a photograph of the interior of a laboratory. It presented the appearance of an ordinary vaulted hall. All was quite excellent. The tables, stones, retorts, lamps, etc., were all seen, only the vaulted ceiling was quite dark. New attempts were made, with exposures of twenty, thirty, or forty minutes. At length a trace of the vault appeared; but now the objects in the vicinity of the window were suffering from too much exposure; that is, they had become as white as if they had been snowed over. This circumstance of photography exaggerating the dark parts appears again in very simple matters, such as the reproduction of copper-plates. A photographer once reproduced a painting of Kaulbach's "Battle of the Huns." He produced a charming photograph, but the city in the background appeared too thick and black, and not sufficiently toned off. The customer refused the photograph and demanded another. The photographer made another attempt, giving a longer exposure, and now the distance appeared softened down; but, unfortunately, the objects close at hand, which had to appear black and clear, turned out gray. In the end, the photographer escaped from the difficulty by negative *retouche.* These are quite ordinary examples to show how difficult it is to reproduce an object correctly.

But we come now to the worst point, that of color. Photography gives the cold colors—blue, violet, and green—too light, and the warm colors too dark. Take as an instance the photographs on sale of "Sunset on the Ganges," by Hildebrandt. It represents a red glowing sun, with clouds of chrome-yellow on an ultramarine sky. But what becomes of all this in the photograph? A black round disk between black thunder-clouds. It looks like an eclipse at Aden. The difficulty of representing Nature is still more patent when the photographer attempts to grapple with higher artistic questions. Let us take an example. There exists a pretty *genre* picture called "A Mother's Love." A mother sits reading in an arm-chair; her little darling embraces her suddenly from behind, and, delightfully surprised, she drops her hand with the book, turns to look at her little pet, and offers her cheek to the little boy to kiss.

A photographer was inspired with the idea of producing a similar picture with the help of a living model. He found a comely maiden, who agreed to personate the mother, and a good-looking boy was also found. An arm-chair for the mother, a chair, and other suitable furniture, were easily procured. The next point was the grouping. The pseudo-mother was very accommodating to the requirements of the photographer, and even assumed a look which, for want of a better, might pass as the expression of a mother's love. But the boy was not of the same mind. He was by no means attracted by the pseudo-mother—he protested against coming near her, and a good cuff was needed to make him take up the requisite position. Time was thus lost. The mother began to feel uncomfortable in the irksome position, straining her neck. The photograph was taken at last, and turned out sharp and without spot or blemish. The models were dismissed, to their great satisfaction. What was the result? The boy was embracing his mother with a face bearing evidence of the cuff he had received, and with a look as if he would have liked to murder her; and she regards him with an expression that seems to say, "Charles, you are very unmannerly," and appears greatly annoyed that her pleasant reading has been interrupted. Can it be said that a picture of this kind correctly expresses the intention of the artist? Does the picture thus produced correspond accurately to the legend, "A Mother's Love?" The untruthfulness of such a picture will be evident to every one.

Thousands of pictures of this class are offered for sale. About ten years ago errors of this kind were committed by the thousand in stereoscopic views, and if they meet with approval this must be referred exclusively to the bad taste of the public. But it may be said in this case it is not the photographer who is guilty, but the unwilling models.

Nevertheless, it is this very circumstance that throws such immense difficulties in the way of taking good photographic portraits. Many persons by no means wish that their characters should be correctly given. The rascal wishes to appear an honorable man in his picture; tottering old men desire to appear young, foppish, and lively; the maid-servant plays the fine lady in the *atelier;* the tradesman's daughter would be a court lady, the street-sweeper a gentleman. Thus the picture serves them only as a means of flattering their personal vanity; and, in order that these people may appear very noble and distinguished, they put on a Sunday's dress, often borrowed and a very bad fit. They practise at home, moreover, before their looking-glass, in the presence of papa, mamma, wife, or lover, impossible attitudes in an artistic point of view. Even cultivated persons are not exempt from these absurdities. Thorwaldsen relates of Byron, who gave him a *séance*, "He sat down opposite to me, but assumed, immediately I commenced, a perfectly different expression. I called his attention to this. 'That is the true expression of my face,' replied Byron. 'Indeed,' I rejoined, and then made his portrait exactly as I wished. All persons declared my bust to be an excellent likeness. But Lord Byron exclaimed, 'The bust does not resemble me; I look much more unhappy.' The fact was, that at that time he wished to look intensely miserable," adds Thorwaldsen. The photographer is even in a worse case. If Byron had come to a photographer, and had presented his face of misery to the camera, what could the photographer have done? He is unfortunately dependent on the model, and many models leave him in the lurch at the critical moment, often not intentionally, but from nervousness or inadvertence. Much depends here on the influence of the photographer, who must know how to control his sitters with courtesy; but many portraits fail without any fault on his part. The author has often witnessed how persons of his acquaintance, at the moment of being taken, assume quite a strange expression without being in the least aware of it.

There are still more characteristic cases of photographic inaccuracy which cannot be attributed to the models. Let us suppose that a photographer, stimulated by the beautiful pictures of Claude, Schirmer, and Hildebrandt, wished to photograph a sunset. He evidently can only expose his plate for a moment to the dazzling bright sun. What sort of a picture is the result? A round white blotch and some shining clouds around it. That is all that appears clearly. All objects in the landscape—trees, houses, and men—have had too short an exposure, and form a black mass. There, where the eye clearly distinguishes road, village, forest, and meadow, it sees in the photograph nothing but a dark patch without any outline. Is such a picture true? Even the most fanatical enthusiast of photography will not dare maintain this.

Such cases, where violent contrasts of light and shade make the production of a correct picture quite impossible, are countless in number. Let any one examine the majority of the photographs of the white Royal Monument in the Thiergarten at Berlin. The monument is excellently given, but the background of trees is a confused black mass, without details, without shades of tone; the architecture and other features are there, all except the splendid foliage that delights the eye at that spot. Still more numerous are the photographs of rooms, in which the dark corners, quite discernible to the eye, present nothing but pitchy-black night. There are other cases, besides these, of photographic incorrectness.

Suppose we are looking at a mountain landscape. A small village, inclosed on both sides by woody hills, occupies the centre, its houses extending along the declivities and scattered picturesquely among the trees. A ridge of finely-broken mountains in the background, their summits shining in the setting sun, frames in the wonderful picture, whose effect is only injured by one object—a ruinous pig-sty close to the spectator, with a dung-heap beside it. A painter, wishing to paint this scene, would certainly have no scruple about altogether leaving out the pig-sty, or leaving it so indistinct and dark that it would not injure the landscape. But what is the photographer to do? He cannot pull down the offending object. He seeks another position; but there the greater part of the landscape is concealed by trees. He ends by admitting the pig-sty, and what kind of picture is the result? On account of its vicinity, the pig-sty appears of colossal size in the picture. On the other hand, the landscape, which is the principal thing, appears small and inconsiderable. A still more fatal adjunct is found in the dung-heap occupying almost one-fourth of the picture. As the most brightly-lighted part of the photograph, it immediately attracts the eye of the beholder; it diverts his glance from other important points; it acts as a disturbing influence. The photograph obtained does not appear as a picture of the landscape, as it ought to be, but as a view of the pig-sty! The accessory has become the principal point. The picture is untrue. It is untrue, not because the objects it represents were not present in Nature, but because the accessories are presented too glaringly and too large, while the principal parts appear too small, indistinct, and inconsiderable.

This brings us to a weak point in photography, which represents accessories and principal features as equally defined. The plate is indifferent to every thing, while the genuine artist, in reproducing a view of Nature, gives prominence to what is characteristic, and entirely keeps under or softens off accessories. He can dispose and manage it with artistic freedom, and he has a perfect right to do so, because, by his giving prominence to what is characteristic, and dropping what is accessory, he is truer than photography, which gives equal prominence to both, and often more to what is accessory. Reynolds says of the portrait of a lady in which an apple-tree was most carefully painted on the background, "That is the picture of an apple-tree and not of a lady." Similar remarks might be made on seeing many photographs. It is a cardinal error in their case, that they give a stronger tone to accessories than to essentials. They present a conglomerate of furniture, and it is only after careful inspection that a man is detected sticking among it, whose portrait is to form the picture. In another case a quilted white blouse is seen, and it is only after some time that a girl's head is perceived rising above it. A park is seen in a landscape, with fountains and other adornments, and it is only after some time that a black coat is seen confounded with an equally dark bush.

It may, perhaps, excite surprise that the writer ascribes greater truth to painting than to photography, which is generally regarded as the truest of all methods of producing pictures. It must be self-evident that the remark has only been made in connection with works of the first masters. One of the great services of photography is that it has rendered impossible those daubs of inferior artists formerly offered for sale in every street. But the perfect picture of the photographer is not self-created. He must test, weigh, consider, and remove the difficulties which oppose the production of a true picture. If his picture is to be true, he must take care that the characteristic is made prominent and the accessories subordinate. The non-sensitive plate of iodide of silver cannot do this. It receives the impression of all that it has before it, according to unchangeable laws. The photographer attains this end, on the one hand, by appropriate grouping of the original; on the other, by a proper treatment of the negative. I admit that to do this he must also be able to detect what is characteristic and what accessory in his original.

Therefore, whoever wishes to undertake any photographic production must first become familiar with the object that he wishes to take, that he may know what he has to do. The photographer will not, indeed, be able to control his matter, like the painter, for the disinclination of models and the optico-chemical difficulties often frustrate his best endeavors, and hence there must always be a difference between photography and a work of art. This difference may be briefly summed up by saying that photography gives a more faithful picture of the form, and art a more faithful picture of the character.

MANUFACTURE AND CONVEYANCE OF GUNPOWDER.

By A. HILLIARD ATTERIDGE.

A LITTLE before five o'clock on the morning of the 2d of last October, a train of four barges was being towed by a steamer along the Regent's Canal, in the northwestern district of London. The second of these barges was laden with a miscellaneous cargo, packed in such a manner, and containing such elements, that the barge was really a very efficient kind of torpedo. In her hold there were about five tons of gunpowder and a quantity of benzoline in kegs. This benzoline may be described as a very volatile species of petroleum. At ordinary temperatures it gives off a highly-inflammable vapor, and this, when mingled with the air in certain proportions, becomes explosive—the explosion running through it at the rate of about two feet per second when it is confined in a tube. In the case of the barge on the Regent's Canal, the cargo was closely covered with a tarpaulin, to protect it from the weather. From the moment, then, that this covering was put on by the bargemen, the vapor given off by the benzoline began to accumulate in the hold, and mingle with the air confined in the spaces between the various packages of the cargo. Thus the hold gradually became filled with a fiery explosive atmosphere, and all that was wanted to produce an explosion was contact with flame. In the little cabin, at the stem of the barge a fire was burning, and there was an aperture in the bulkhead, or partition, which divided the cabin from the hold. Through this the benzoline vapor entered the cabin, and the air in it was soon as vitiated as that under the tarpaulin in the hold. It was ignited by the fire; the explosion, beginning in the cabin, ran forward in a few seconds to the bow, and fired the gunpowder stowed there.

Every one knows what followed. Half London was awakened by the report, which was heard for miles around—to the northward as far as Finchley and Enfield, to the southward as far as Blackheath and Woolwich. Within a radius of from half a mile to a mile from the scene of the explosion houses were wrecked, windows blown in, doors burst open, ceilings shaken down, ornaments and furniture dashed to pieces. A massive bridge over the canal was destroyed, for hundreds of yards its embankment was displaced, and the house which stood nearest to it was so shaken that it had to be pulled down next day. The effect was more like that of a severe shock of an earthquake than any thing else. Fortunately no lives were lost except those of the crew of the barge, but the destruction of valuable property was enormous.

Much alarm has been caused not only in London but throughout the kingdom by this explosion in the heart of the metropolis, and it will have a useful effect in calling attention to the dangerous character of a material so largely employed as gunpowder, and the consequent necessity of carefully regulating its manufacture, storage, and transport, and seeing that these regulations are strictly enforced; for, no matter how perfect our precautions may be in theory, they are worse than useless if we cannot secure their practical efficiency. Without this, their only result must be to lull us into a false security. Gunpowder, and its manufacture and transport, are now subjects in which nearly every one is interested; and we purpose to devote the following pages to an account of the nature and action of this explosive, its manufacture, and the principles involved in it, and, finally, its transport, and the precautions necessary for our security against explosions like that of last October. We shall describe the process of manufacture in use at the Government mills, as these are probably the most perfect and efficient in the kingdom.

Fifteen miles to the northeast of London, between the sluggish stream of the River Lea and the northern heights of Epping Forest, stands the little village of Waltham, famous for its old abbey, founded by the last Saxon King of England, and destined to be his tomb after the fatal field of Hastings. On both sides of the high-road beyond the village extends a wide tract of flat alluvial ground, traversed by the branches of the Lea, and rich in plantations of willow and alder, with here and there stately rows of poplars. A tall chimney-shaft, the roofs of scattered buildings, and a range of houses near the road, indicate that these well-planted fields are the site of the Royal Gunpowder Factory.

The Waltham Abbey Mills are probably the oldest in Great Britain. They must have been established about the middle of the sixteenth century, for we know that before that time nearly all the powder used in England was imported from the Continent. But in 1561 we hear of John Thomworth, of Waltham, buying, as agent for Queen Elizabeth, saltpetre, sulphur, and staves for making barrels. In the following century the parish register shows entries of deaths resulting from explosions at the mills; and Fuller, who was Rector of Waltham, alludes in one of his works to the dangers of the manufacture, remarking that the mills were blown up five times during the seven years of his residence in the parish. The only wonder is, that explosions were not far more frequent in the old factories, where the elaborate precautions now adopted were utterly unknown. Powder was allowed to accumulate in heaps on the floor, spirits of wine was used instead of water to moisten the ingredients, under the impression that it made better and stronger powder, and the drying process was effected by heating the powder on metal plates over a fire without any means of regulating the temperature. Finally, all the workrooms were close together, and often under a single roof, so that, if the powder in one room exploded, that in the rest would follow, like a boy's train of crackers.

It was in 1787 that Government bought the Waltham Mills from the last private proprietor, Mr. John Walton, supposed by some to have been a descendant of the family of old Izaak. Major (afterward Sir William) Congreve was the first superintendent. Horse and water power only were employed, most of the machinery was of wood, and the incorporating mills were, like mortar-mills at the present time, worked only by horses. Since then great improvements have been introduced into the manufacturing process; the factory has been widely extended, gun-metal and copper have been largely substituted for wood in the structure of the machines, refining-houses have been erected for purifying the saltpetre and sulphur, and retorts for preparing the charcoal. Machinery has been designed and erected for the preparation of the large cannon-powder introduced of late years, and in the mills iron runners, driven by steam, have taken the place of the stone runners, drawn by old horses. A complete code of rules and precautions has been introduced, and every building protected by a system of lightning-conductors. The factory gives employment to about two hundred men, and can produce twenty-four thousand barrels of gunpowder in the year, and the powder is believed to be at once the best and cheapest made by any existing factory.

Before describing the process of its manufacture at Waltham, it may be as well to note a few facts on its composition and action. Gunpowder may be regarded as a solid, which, by ignition, can be very rapidly converted into a large volume of gas at a high temperature. It is this quality which constitutes it an explosive, for the sudden expansion is what we call explosion, though the name is sometimes given to the loud report which accompanies it, caused by the outrush of the gas generating sound-waves in the air. When the explosion occurs in a confined space, the weakest portion of the confining bodies gives way before it. In quarrying, the rocks are rent, as the gas from the blasting-powder forces them apart. In blowing down walls and gates, the mass of earth heaped on one side to form the "tamping" offers a greater resistance than the wood or stone on the other, and the wall or gate gives way. In firing a cannon, the loose shot offers less resistance than the solid coils of the gun, and it is driven out to a distance proportioned to the force of the charge. If there is any defect impairing the strength of the cannon, or if the shot wedges in the bore, the gun bursts; for nothing we know of can resist the force of the gas. Recent experiments prove that this force, exerted in closed vessels unrelieved by expansion, is equal to a pressure of about forty tons on the square inch.

Of the three materials of which gunpowder consists—sulphur, charcoal, and saltpetre—only the last two are, strictly speaking, essential to it. The gas is actually generated from the charcoal and saltpetre, therefore a mixture of these only will explode. On ignition the charcoal decomposes the saltpetre, its combustion being supported by the oxygen of the latter, in combination with which it forms carbonic-acid gas, and this, mixed with the nitrogen from the saltpetre, is the *gas* which produces the useful effect. But, when gunpowder is thus made with saltpetre and charcoal only, the power developed by the explosion is comparatively trifling, and sulphur has to be added to increase it to such an extent as to make it really efficient. The sulphur acts in two ways to this end. In the first place, it ignites at a lower temperature than either charcoal or saltpetre, and its combustion accelerates both the decomposition of the saltpetre and the generation of gas, by combining with the potassium of the saltpetre and liberating the oxygen. Then, by heating the carbonic acid and nitrogen, it considerably increases their volume, and consequently their explosive force. The flash, and smoke, and the fouling of the gun, are the result of the decomposition of the saltpetre, and consist of sulphates and carbonates of potassa, resulting from the combination of potassium with the sulphur and carbon. The substances thus formed, swept out into the air, become flame and smoke, or remain in the bore of the gun as fouling, and it is these solid substances that blacken the faces of men engaged in close conflict.

Thus we see that of the materials of gunpowder saltpetre is the most important. Both saltpetre and sulphur arrive in England in a rough state, mixed with various impurities. It is generally the practice in private factories to purchase these materials after they have been refined elsewhere; but at Waltham the refining process is carried on within the works. By this means the materials are obtained of a uniform quality and perfectly pure. The saltpetre comes from various districts of India, chiefly from Bengal and Oude, where it is found mixed with the soil, and as an incrustation on the ground. In India it is boiled, and roughly crystallized by evaporation. When it is required for use in the Gunpowder Factory, it is purified by a process founded on the principle that hot water will receive in solution more of the saltpetre than of the impurities mingled with it. The saltpetre is boiled in water; the resulting solution is then filtered and allowed to cool in large vats, at the bottom of which the pure saltpetre is deposited in fine crystals. It is then washed, dried, and stored in bins, great care being taken that no sand or gritty particles are introduced, as they might cause an explosion when under pressure at subsequent stages of the manufacture, and the same precaution is taken with the sulphur and the charcoal. It is believed that many of the explosions which occur in private factories are caused by foreign substances being present in the materials.

The sulphur is all of the best quality, imported from Sicily. It is purified by a distilling process, which reduces it from its rough state to masses of handsome yellow crystals. It is then pulverized by being ground under iron runners, and sifted in a kind of revolving cylindrical sieve, called a "slope-reel." The sulphur refining-house is, of the whole factory, the least pleasant portion for a visitor, the air being always tainted with the fumes of the sulphur, which are so strong as even to burn and destroy the leaves of the trees near the building. The management of the process is, however, by no means an unhealthy labor. The workman last employed at it died as a pensioner at the ripe old age of eighty, after having worked forty years in the refining-house.

The charcoal is all made on the spot, chiefly from wood imported from Holland and Germany. The alders and willows in the plantations of the factory furnish but an insignificant supply, probably not enough to make a dozen barrels in the year. They are grown for the most part to form screens around and between the houses, so as to diminish the danger resulting from a possible explosion. The wood employed is of three kinds—alder and willow, which are used for common powder, and black dogwood for fine rifle-powder for the Snider and Martini-Henry. The latter wood is really a kind of buckthorn (*Rhamnus frangula*), of slow growth, and consequently close grain, which forms dense thickets in the forests of Germany, and is also found in the north of England and elsewhere. It is imported in bundles of slender rods about six feet long, and enormous quantities of these bundles may be seen stacked in the fields of the factory. There it is kept for at least three years, though generally it is allowed to lie in store for a much longer time. Some wood has been kept for twenty years, protected from the weather by a roof of thatch, and is still perfectly sound. Strange to say, comparatively little dogwood is used in the powder-factories of Germany, though it is quite certain that it supplies the best charcoal for the purpose.[1] The old plan for charring wood was to burn it in pits, and this is still the practice abroad, but for many years the charcoal at Waltham has been manufactured by sawing the wood into short lengths, and packing it into iron cylinders called "slips," which are placed on a small carriage, and run into a retort very like those used in gas-works. Here the slip is exposed to the flames for a period varying from two and a half to three and a half hours, the gas issuing from the wood in the process being utilized as fuel; and the superintendent of the work knows when the wood is completely charred, by the peculiar color with which the combustion of the gas tinges the fire. As soon as this appears, the slip is withdrawn and cooled. The charcoal when taken out is ground in a machine like a colossal coffee-mill, and then, like the sulphur, sifted in a slope-reel.

The three ingredients are now ready for the regular process of manufacture to be commenced. Up to a certain point (the formation of the "press-cake") the process is the same for whatever purpose the gunpowder is intended, but at that point it divides into two branches, according as it is to be used for heavy guns or smaller weapons. We shall, therefore, first trace the various stages of the manufacture up to the press-house, and then explain the method of making the various kinds of gunpowder, and the objects desired to be obtained by these modifications.

[1] M. Proust's experiments on charcoal, made from various woods, give the following results: 12 grains of charcoal of each wood, mixed with 60 grains of saltpetre and ignited, yielded the following proportions of gas in cubic inches: Dogwood, 80 to 84; willow, 76 to 78; alder, 74 to 75; filbert, 72; fir, 76; elm, 62; oak, 61 to 63. The importance of not overheating the wood is shown by the fact that, when the charcoal consisted of overheated willow, the yield of gas was only from 59 to 66 cubic inches.

The first process is that of simply mixing the ingredients. For this purpose the proper quantities of each are accurately weighed out, allowance being made for a certain amount of moisture in the saltpetre. The proportions vary in different countries, and according to the purpose for which the gunpowder is to be used. For English Government powder of every kind it is—saltpetre 75 parts, sulphur 10, charcoal 15, the sulphur being reduced almost to a minimum, as its chief use is only to ignite the charge and accelerate its action. In France and Prussia the quantity of sulphur is larger, the scale being saltpetre 75 and 12.5 parts each of sulphur and charcoal, while in Chinese powder the amount of sulphur is between 14 and 15. It is remarkable that in all countries the proportion of saltpetre remains about the same.

The ingredients, being weighed for a charge of 50 pounds, are poured into a "churn." This is a revolving drum, placed horizontally, and having within it an axis revolving in a different direction from the drum, and furnished with eight rows of projecting arms, or "fliers." So rapid is the action of this apparatus, that when the charge has been three minutes in the revolving churn the ingredients are thoroughly mixed together. It is then known as a "green charge," and is ready for the incorporating mills, the object of which, as the name indicates, is to incorporate the materials, or to make the mixture so intimate that a new substance is produced, namely gunpowder.

The incorporating-houses at Waltham contain at present thirty-two separate mills. Each mill consists of a pair of runners, coupled together by a strong axle. This axle rests in the socket of an upright shaft, which, passing down through the mill-bed, is connected by bevel-wheels with a revolving horizontal shaft, driven by steam or water-power. The runners are either of black Derbyshire limestone or of iron, and weigh from three and a half to four tons. Iron runners are now generally used, and their size varies from three and a half to seven feet in diameter. The mill-bed, a large circular vat with a flat bottom and sloping sides, is of stone or metal, according to the material of the runners. On this bed 50 pounds of the green charge is spread out and moistened with water, and the mill is then set going. The length of time required for the incorporation of the powder varies according to the use to which it is to be applied. Thus cannon-powder is left under the mills for three hours; while for rifle-powder, which requires a closer incorporation on account of its more rapid action, the time is five hours. The power of a gunpowder-factory is measured by the number of pairs of runners it possesses, for, as the law allows no more than 50 pounds to be placed in any mill at one time, the amount which can be incorporated in a year is easily calculated. A pair of iron runners, driven by steam and working day and night, will incorporate in a year nearly 100,000 pounds of cannon-powder, or about half that quantity of rifle-powder.

This part of the process is more dangerous than any other, and explosions in the incorporating-mills are very frequent. The houses are built of light planking, nailed on a strong framework, so as to diminish the force of the explosion by yielding easily before it. The men are forbidden to remain in them while the mill is in motion, and a very simple arrangement has been devised for preventing an explosion from extending from one mill to another. A shaft runs horizontally through the upper part of the walls of each row of mill-houses. A shutter, balanced by a weight on the other side of the shaft, projects from it over each mill, and this shutter supports one side of a water-tank, the other resting on a pivot. Now, if an explosion takes place in any of the mills, the shutter above it will be blown up, turning the horizontal shaft, and raising all the shutters attached to it; so that the tanks, being left unsupported, turn over, and drench the contents of the mill-beds below.

On leaving the mill, the gunpowder is in the form of a soft cake, which easily breaks up into meal and dust. The old plan for making gunpowder, still followed in some places, was to moisten this mill-cake and force it through fine sieves, so as to break it into grains; but the moisture partly dissolved the saltpetre, and thus, to some extent, destroyed the previous incorporation, and the result was an inferior gunpowder, which, on account of the softness of the grains, often broke up into dust in transport. In the modern process, the mill-cake is first presssd in layers between plates of copper or gun-metal, to increase its hardness and density, and then made into grains of the required form by machinery. As a preparation for the press, the mill-cake is roughly broken down into meal and dust by being passed between grooved gun-metal rollers. It is then ready to be poured into the press-box.

This is a large box of gun-metal, lined with oak, and capable of holding about 800 pounds of powder. The sides are hinged to facilitate unloading, and by means of a small crane it can be swung into or out of the hydraulic press. To be loaded it is turned on one side, a wooden cover placed on the top, and the uppermost side is turned back on its hinges. Then, by means of gun-metal racks, the plates are arranged in the box, with the proper intervals between them to produce a thick cake for cannon-powder, or a thin one if rifle powder is to be made. The powder-meal is then poured in between the plates, the racks withdrawn, the side closed and bolted down. It is then swung by the crane on to the table of the press, and the cover taken off. The press is an ordinary hydraulic one; the table which supports the box is placed on the head of the ram, and as it rises a block of oak fixed overhead enters the box, and presses the powder, the amount of the pressure being measured by the extent to which the block enters the box. The pumps which supply the press with water are fixed in an adjoining room, and worked by a water-wheel; and, in order that the men may know when the pressing is complete without having to enter the press-room, a kind of catch and trigger is attached to the side of the block, and, as soon as the press-box has been forced up to the required point, the catch is liberated by coming in contact with it, and rings a bell in the pump-room. The pumps are then stopped, the ram falls by its own weight, and the box is unloaded, the gunpowder being taken out in large cakes the size of the metal plates, and as hard as slate. It is in the pressing of the gunpowder that the most serious explosions occur, for, if by any chance the pressure becomes too severe, and the powder explodes in the box, its force is much greater than if it were ignited in the open air. Seven men were killed by an explosion in the press-house at Waltham Abbey in 1843, and by a similar accident on June 16, 1870, five were killed and seven injured.

The question of the density given to gunpowder by pressing and its effects is one which is only now being worked out. Formerly the density of the powder was roughly ascertained by weighing a cubic foot of it, and then its quality was tested by observing to what distance it would fire a shell from a mortar. The primitive methods are now superseded by a testing apparatus, which gives scientifically accurate results. The density is determined by reducing a small quantity of the powder to dust in a mortar, and then placing it in a glass globe provided with stopcocks, one of them connected with an air-pump, and the other with a tube dipping into a vessel of mercury. On exhausting the air, closing the first cock and opening the second, the mercury is forced into the globe, and completely fills it. It is then weighed in a delicate balance, and, its weight when filled with mercury only being known, it is easy to calculate the density of the gunpowder.

Its force is ascertained by observing the initial velocities which it will give to a shot fired from a cannon. These velocities are measured with Bashforth's Chronograph, as explained in a former article in the *Popular Science Review;*[1] and with the Noble Chronoscope, the invention of Captain A. Noble, of the Elswick Works, by means of which we are enabled to ascertain what takes place in the bore of the gun on the explosion of the charge, and what is the velocity of the shot, not only in the whole length of its course within the gun, but also in each portion of that short distance, thus determining the velocity within very small limits both of time and space, and this with the most perfect accuracy.

It is difficult to describe the chronoscope without a diagram, but it is easy to indicate the general principles of its action in a few words, and this will be sufficient for our purpose. A gun having been selected for the experiment, six or eight holes are drilled in one side of it, penetrating to the bore, at intervals along its length from the seat of the shot to the muzzle. Through each of these holes an insulated wire

[1] "On the Striking Velocity of Shot." By W. Royston Pigott, M. D., P. S. R., January, 1871.

enters the gun, its lower extremity being in contact with, but insulated from, a sharp cutting edge, so arranged in the bore of the gun that the passage of the shot would force it down upon the wire and destroy the insulation. Each of the wires is connected with the secondary wire of an induction coil. The recording apparatus consists of a series of disks of polished silver, coated with lamp-black, and made to revolve simultaneously by the action of a falling weight and multiplying wheels at a very high velocity. One of these disks corresponds to each of the wires, the end of which is placed in a small discharger close to its circumference. On firing the charge, the shot cuts the insulation of wire after wire in rapid succession, and as each is cut a current passes, and a spark darts from the discharger to the edge of the revolving disk, striking off a speck of the lamp-black, and leaving the bright silver bare. Now, supposing the velocity of the circumference of the disks to be 1,000 inches per second, and the mark of the electric spark on the second disk to be one inch farther on than that upon the first, this would show that the shot took the $\frac{1}{1000}$ part of a second to pass from the first wire in the gun to the next. Similarly, if the distance between the marks on the first and last disks were five inches, this would indicate that the time the shot took to traverse the whole length of the gun was five-thousandths, or $\frac{1}{200}$, of a second. In reality, the time is even shorter than this. In the 10-inch gun, a 300-pound shot, with a charge of 43 pounds of powder, passes down the bore in something less than the $\frac{1}{220}$ part of a second. So delicate is this apparatus that, by dividing each inch of circumference of the disks into thousandths with the help of the vernier, the $\frac{1}{1000000}$ part of a second would become an appreciable quantity.

It is found, by careful experiment with these appliances and the crusher gauge (by which pressure is estimated by the compression of a copper cylinder placed in the bore of the gun), that the denser the powder is the slower it burns, giving a lower initial velocity to the shot, and exerting a smaller strain on the gun. As an instance of the great differences caused by the smallest variations in density, we give the following results of an experiment with the 10-inch gun, with a charge of 70 pounds:

Density.	Initial Velocity, Feet per Second.	Maximum Pressure, Tons on Square Inch.
1.732	1474	29
1.782	1432	21

Here an increase of .05 in density reduced the velocity by forty-two feet, and the pressure by eight tons. This shows the importance of obtaining a uniform density in the manufacture. For this purpose it is not sufficient to use a uniform pressure in the press-house, as even then the density of different pressings will vary on account of the changing state of the atmosphere, the different degrees of moisture in the powder-meal, its varying bulk and elasticity, and other minor causes. The only practicable method of securing an approximately uniform density is to test the product of various pressings and then mix them, so as to reduce the whole to the average density required, and this is the constant practice at Waltham.

We have alluded incidentally to the decrease of pressure in the gun as the density of the powder increases. With the immense guns constructed in recent years, it is important to reduce the strain on the metal as far as possible, as this is the only way in which the gun can be safely fired. But it must be remembered that, by seeking to accomplish this by indefinitely increasing the density of the powder, we would at the same time decrease the velocity of the shot, or, in other words, its useful effect. Artillerists have, therefore, had recourse to the expedient of using a powder, each grain of which is a lump of press-cake. The effect of this is to make it burn slower than grain-powder; for these lumps, when ignited at the surface, burn, as it were, in concentric layers, until the whole is consumed; and by this means the explosion, though to all appearance instantaneous, is in reality much more gradual than that which follows the ignition of smaller grains. In other words, the explosion of the charge in a heavy gun is made to be less of the character of a violent blow on the sides of the bore and the base of the shot, and more like a gradual shove given to the shot with a corresponding pressure on the gun.

The first form proposed for cannon-powder for heavy guns was that invented in America by Dr. Doremus, in which the whole charge was made into a solid disk, the size of the bore of the gun. This, however, was found to give very unsatisfactory results. Then the Russian Government adopted a powder compressed into large hexagonal prisms, and in Belgium another powder was made in the form of cylindrical pellets. This was adopted by our Government, and an immense sum was spent on erecting machinery at Waltham for its manufacture, but the pellet-powder has since been superseded by a simpler form, much easier to make, and giving better results; and the pellet machinery has been altered, and, we believe, is now used in the manufacture of gun-cotton.

The pebble-powder now in use consists of cubes of compressed gunpowder, with sides about four-fifths of an inch square. These pebbles are made by passing press-cake of that thickness between two pairs of rollers, armed with sharp-cutting edges. The first pair of rollers, by means of these edges, cuts the cake into several small bars, about four-fifths of an inch square at the ends, and these bars, on passing between the second pair of rollers, are divided into cubes or pebbles. After having been rolled in a hollow cylinder, or reel, to round off the sharp edges and get rid of the dust, the pebbles are carried to the drying-house to be freed from the moisture they contain.

The drying-house is a large room with double doors, and fitted with racks from floor to ceiling. On these racks copper and wooden trays are placed, containing the powder, spread out in thin layers. Steam-pipes are introduced from a boiler in an adjoining building, and thus the air of the room is kept at a temperature of about 135°. The firemen in charge of the drying are forbidden to enter the room for fear of carrying in a spark in their clothes, but they ascertain the temperature by a register thermometer placed inside a small window, and this thermometer also acts as a telltale, by showing if the temperature has at any time been allowed to become too high or too low. So perfect are all the arrangements at Waltham, that no explosion has ever occurred in the drying-house.

The dried pebbles are finished by being placed in a revolving barrel (called a glazing-barrel), with a certain amount of powdered black-lead. On being taken out, every pebble is found to have a perfectly smooth surface coated with black-lead, the effect of which is still further to diminish the rate of burning. The pebbles are then thrown into sieves to separate small fragments; all irregular pieces are picked out by hand, and the remainder is packed in ordinary powder-barrels, which would hold 100 pounds of rifle-powder, but contain 125 pounds of the pebble-powder, on account of its greater density.

The following results of experiments with the 8-inch gun will give the reader an idea of the effects of the different kinds of powder. We need only explain that R. L. G. means the old "Rifle Large Grain" powder, still in use for field-artillery, and draw attention to the fact that the pebble-powder gives at once the highest velocity and the lowest strain:

POWDER.	Charge, Pounds.	Initial Velocity, Feet per Second.	Maximum Pressure, Tons on Square Inch.
R. L. G..........	30	1324	29.8
Russian Prismatic.	32	1366	20.5
Service Pellet....	30	1338	17.4
Pebble..........	35	1374	15.4

Visitors to the laboratory at Waltham can see there a number of experimental varieties of pebble-powder, the largest of which consists of cubes as hard as stone, each side of which is two inches square. A shower of this alone fired from a gun would be quite as effective as grape, and it is possible that 300 pounds of this tremendous powder will form the charge of the new 80-ton gun.

For rifle-powder the meal is pressed into thin cakes; these are broken up into irregular pieces by hand, and carried to the granulating machine. This machine consists of four pairs of toothed cylinders, between which the broken cake is passed. As it falls from them in grains, it is received upon a series of screens of net-work. There are three of these, the texture of each being closer than that above it, so that large-grain powder is retained on the first, while fine-grain and dust fall through it. The fine-grain remains on the second, and the dust passes on to the third. All the screens are placed in an inclined position, so that the powder runs down them into tubs arranged at the lower end, one of which receives the large, another the fine-grain, and a third the dust.

The powder is then rolled for some hours in the glazing-barrels, to break off all minute irregularities, and give it a smooth surface. Then it is dried, and finally freed from dust in the slope-reel. This done, it is finished by being passed once more through the glazing-barrels, and it is then packed in barrels of 100 pounds each.

Such is the process of the gunpowder manufacture in the Royal Factory at Waltham. We have only briefly indicated the principles of each process, for to go into detail would occupy far greater space than is at our command; but even this sketch will show how at each step science has been called in to aid art in bringing the manufacture to its present high state of perfection. No expense is spared in procuring the best materials, the most efficient machines, and the most accurate tests; yet the cost of manufacture is only about sevenpence per pound. What a contrast to the early days of gunpowder-making, when in France, in 1375, a pound of gunpowder cost a sum equal to ten pounds of our money!

In every department the greatest care is taken to prevent the danger of explosions. The houses are built from 200 to 400 yards apart. Wood, copper, and gun-metal, are the only materials used in the structure of the machines, except where, and that rarely, a bolt of iron is introduced for the sake of strength, and then the metal is encased in leather. The floors are covered with hides secured with copper nails, and these, as well as the wooden platforms round the houses, are kept constantly wet. All loose powder is swept away from the floors, damped, and carried to a magazine, where it is collected and the saltpetre subsequently extracted. No one is allowed to enter a room without putting on a pair of leather "magazine shoes" made without nails, as the iron nails in ordinary boots might lead to an explosion if one trod on the loose powder; and, moreover, one would be certain to bring in grains of grit, which are so dangerous if they become mixed with the powder. The men wear a kind of fire-proof clothing, and in the incorporating-houses leather caps and gloves. Fire-engines are stationed in various parts of the factory, and every man has his post assigned to him in the event of an alarm of fire. To such an extent are these precautions carried that the roofs and eaves of the buildings are searched for birds' nests, and they are pulled down whenever they are found, lest the birds, in building or bringing food to the young, might drop grains of grit or sand on the platforms round the houses. Every building is protected by lightning-conductors, and, as soon as a thunder-storm approaches, the men have orders to stop the machinery, leave the houses, close the doors, and cease all work until it has passed over. But the best security for the safety of the factory is that the workmen are a body of steady, industrious, intelligent men, and bear so high a character that a dismissal is a rare event, though it is the penalty of any breach of a necessarily strict code of rules.

The powder manufactured at Waltham is carried down the river Lea to be stored in the great magazines at Purfleet. A useful lesson can be learned from the method of transport. The gunpowder is conveyed in barges specially constructed for the purpose. They are about half the length of an ordinary canal-boat, and are covered with a semicircular roof, with a door at the side, which is kept closed, except when the boat is being actually loaded or unloaded. Every powder-barge is considered a magazine, and the same rules apply to it as to the Government magazines. No fire or light is allowed on board; nothing but powder is to be placed in the hold; and no one is allowed to enter it without wearing the ordinary magazine shoes. In this way it may be said that every chance of an explosion is carefully guarded against. It would be well if the same method of transport were used on canals where (as on the Regent's Canal) gunpowder is being continually carried to and fro. The extra expense of having special barges would not amount to one-hundredth part of the loss caused by an explosion.

We have also to consider the transport of gunpowder by road. It is said that it is a common thing for cart-loads of gunpowder to pass through the crowded streets of London, sometimes several carts closely following each other, and crowding together if there is a block in the traffic. This is unquestionably a very dangerous practice. It would be well if carts laden with any considerable quantity of gunpowder could be prevented from entering the streets of a town; but in many cases this would be impossible. The transport, however, might easily be rendered much safer, by forbidding gunpowder-carts to pass along the streets except during a few hours in the morning, allowing only covered vans to be used, and fixing certain intervals within which no van should approach another. Finally, powder should never be packed in the light kegs used by some manufacturers, which are continually liable to leak, for loose powder is always exposed to ignition by any one of a hundred accidents. There are cases recorded of explosions having taken place through powder leaking from a tumbril, and forming a train upon the ground, which was fired by a spark struck from the shoes of one of the horses drawing it. Good, strong barrels should always be used, and they could of course be returned when empty.

After the Regent's Park explosion there were some fears expressed as to a possible explosion at Purfleet, where about 50,000 barrels of gunpowder are stored in five large magazines. If five tons on board the canal-barge could do so much damage, what, it was asked, would be the effect of an explosion of the 2,000 tons at Purfleet? Attempts were made to calculate the radius of destruction by Mallet's formula for the effect of bursting shells—the fact being disregarded that the bursting of a shell and the blowing up of a magazine are essentially different affairs. We were told how all East London would suffer from the shock, how several villages in Kent and Essex would be destroyed, and how trains would be thrown off the railway-lines, gasometers wrecked, and a wide district plunged into darkness. We must not forget that an explosion in the open country would have relatively much less force than an explosion in the midst of closely-built streets like those about Regent's Park. An explosion at Purfleet would be very terrible, but probably not half so destructive as one might expect at first sight.[1] Then the Government must keep this large store of powder somewhere; 50,000 barrels could not be manufactured on an emergency, and Purfleet offers advantages in the way of safe and easy transport from Waltham, and shipment to India and the colonies, which mark it as a good site for our chief magazines. The gunpowder might indeed be distributed in numerous magazines, at various points along the lower part of the Thames, but this would really be to increase the chances of an explosion; for, the more numerous is the staff of superintendents and store-keepers, the greater is the danger of carelessness on the part of some among them.

Many a one has said, with the foppish young lord, who so much excited the anger of Hotspur at Holmedon:

> ". . . That it was great pity, so it was,
> That villainous saltpetre should be digged
> Out of the bowels of the harmless earth,
> Which many a good tall fellow had destroyed."

But, strange as it may seem at first sight, gunpowder and such compounds are as much used in peace as in war. What with practising, salutes, experiments, and reviews, our army, navy, and volunteers, burn every year as much gunpowder as would be required for half a dozen battles and a siege or two. But it is in mining, quarrying, and engineering works, in a word, for industrial purposes generally, that gunpowder is chiefly used; and as strife and peaceful industry cannot exist together, a war, on the whole, tends to lessen rather than increase the consumption of explosive substances. During the great conflict in America the sale and import of gunpowder fell off enormously. It is said that the same thing was noticed in France during the Crimean War; and probably the present war in Spain, by stopping the iron-mines of the north, has diminished the import of blast-

[1] The explosion of a large magazine is really the successive explosion of various portions of its contents, not the detonation of the whole mass. This is why it is fallacious to attempt to estimate the effect of the explosion of 2,000 tons by comparing it with the explosion of a large shell, or of a few barrels on board a barge.

ing-powder to a greater extent than it has accelerated that of powder specially manufactured for military purposes.

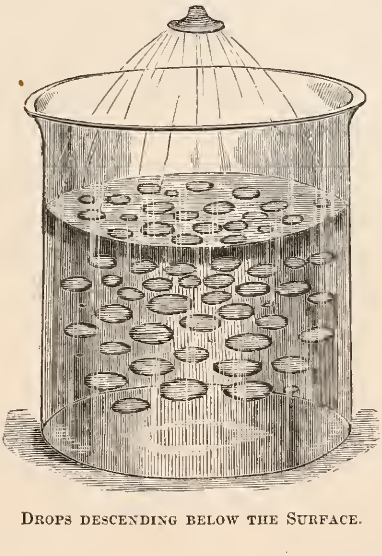
The following figures will give an idea of the amount of gunpowder employed in mining operations: It is estimated that in coal-mines about 80 pounds of powder are used for every thousand tons of coal raised. In mines of lead and other minerals, which are found in hard crystalline rocks, about 7,000 pounds of blasting-powder are required for every thousand tons of ore. To quarry a similar quantity of sandstone 170 pounds would be used; while for the harder granite the amount would be 650 pounds.

The quantity of gunpowder exported from England has not increased very rapidly of late years. In 1860 it was 11,078,436 pounds, of a declared value of £353,101. In 1865 it had risen to 16,833,723 pounds, valued at £457,078; and in 1870 it was 17,357,668 pounds, valued at £427,229. The increase in weight, with a decrease in value from 1865 to 1870, is due in a great measure to the fact that we export an immense quantity of gunpowder of an inferior quality to non-British ports in Western Africa; and it is in this cheap sort of gunpowder that the chief increase has taken place, while there has been a falling off in the more valuable kinds. Thus, in 1870, no less than 4,637,066 pounds, or more than 25 per cent. of the whole export, went to Western Africa, chiefly to satisfy the warlike propensities of woolly-headed kings; but it will be seen at once what the quality of the powder was, when we add that its declared value was only £83,657, while the comparatively small quantity of 1,173,762 pounds, exported to France, was worth £75,522, or about four times as much in proportion to its weight. Heavy as our loss was at Amoaful, it would have been much more severe if the Ashantees had been provided with something better than this worthless powder. As it was, several of the men in the front line were struck five or six times without being wounded, the bullets having such little force that they fell harmlessly to the ground.—*Popular Science Review.*

RAIN-DROPS ON THE SEA.

By Prof. OSBORNE REYNOLDS, M. A.

THERE appears to be a very general belief among sailors that rain tends to calm the sea, or, as I have often heard it expressed, that rain soon knocks down the sea. Without attaching very much weight to this general impression, my object in this paper is to point out an effect of rain on falling into water which I believe has not been hitherto noticed, and which would certainly tend to destroy any wave-motion there might be in the water. When a drop of rain falls on to water the splash or rebound is visible enough, as are also the waves which diverge from the point of contact; but the effect caused by the drop under the surface is not apparent, because, the water being all of the same color, there is nothing to show the interchange of place which may be going on. There is, however, a very considerable effect produced. If instead of a drop of rain we let fall a drop of colored water, or, better still, if we color the topmost layer of the water, this effect becomes apparent. We then see that each drop sends down one or more masses of colored water in the form of vortex rings. These rings descend with a gradually diminishing velocity and with increasing size to a distance of several inches, generally as much as eighteen, below the surface. Each drop sends in general more than one ring, but the first ring is much more definite, and descends much quicker than those which follow it. If the surface of the water be not colored, this first ring is hardly apparent, for it appears to contain



DROPS DESCENDING BELOW THE SURFACE.

very little of the water of the drop which causes it. The actual size of these rings depends on the size and speed of the drops. They steadily increase as they descend, and before they stop they have generally attained a diameter of from one to two inches, or even more. The diagram above shows the effect which may be produced in a glass vessel. It is not that the drop merely forces itself down under the surface, but, in descending, carries down with it a mass of water which, when the ring is one inch in diameter, would be an oblate spheroid, having a larger axis of two inches and a lesser of about one and a half inch. For it is well known that the vortex ring is merely the core of the mass of fluid which accompanies it, the shape of which is much the same as that which would be formed by winding string through and through a curtain-ring until it was full. It is probable that the momentum of these rings corresponds very nearly with that of the drops before impact, so that when rain is falling on to water there is as much motion immediately beneath the surface as above it, only the drops, so to speak, are much larger, and their motion is slower. Besides the splash, therefore, and surface-effect which the drops produce, they cause the water at the surface rapidly to change places with that at some distance below. Such a transposition of water from one place to another must tend to destroy wave-motion. This may be seen as follows: Imagine a layer of water adjacent to the surface, and a few inches thick, to be flowing in any direction over the lower water, which is to be supposed at rest. The effect of a drop would be to knock some of the moving water into that which is at rest, and a corresponding quantity of water would have to rise up into the moving layer, so that the upper layer would lose its motion by communicating it to the water below. Now, when the surface of water is disturbed by waves, besides the vertical motion the particles move backward and forward in an horizontal direction, and this motion diminishes as we proceed downward from the surface. Therefore, in this case, the effect of rain-drops will be the same as in the case considered above, namely, to convey the motion which belongs to the water at the surface down into the lower water, where it has no effect so far as the waves are concerned, and hence the rain would diminish the motion at the surface, which is essential to the continuance of the waves, and thus destroy the waves.—*Nature.*

SCIENCE FROM THE PULPIT.

By JOHN TROWBRIDGE,

ASSISTANT PROFESSOR OF PHYSICS IN HARVARD UNIVERSITY.

ARE ministers fitted to discuss the bearing of modern science upon religion? This question forces itself upon one who is both a member of a church and a lover of science, and deserves to be carefully weighed by those who have the interests of Christianity at heart. An article by the editor of the *Nation*, in the issue of December 24, 1874, takes the very sensible ground that a man of science should have no greater authority in controverted religious questions than the most humble member of a church. His views are not entitled to great consideration simply because he is a student of science. This seems to touch the vital part of the question. The history of the world shows, however, that the assumption of exclusive right to treat religious questions with authority, and the barring out of critical intruders, have always come from a class of men who are peculiarly unfitted by education to see the bearing of modern investigation. The Church should be eager to receive the discoveries of investigators of the strange and wonderful works of the Creator, with confidence that all can and must be reconciled with revealed religion. We see very little of this eager, receptive condition among ministers. On the contrary, the occupants of the pulpits immediately assume a fretful condition of indignation. They bristle at the very mention of the doctrine of evolution, of prehistoric man, and the theories of the antiquity of the world.

The address of Prof. Tyndall has been criticised from a hundred pulpits. If carefully read, it will not be found to afford material for the wave of indignation which has swept over the religious world. The address was evidently inspired by an indignant feeling of protest against religious dictation in science, which was tinctured also by a certain want of reverence characteristic of many scientific men. This deficiency in reverence is to be lamented, but the attitude of an investigator is generally one of irreverence. Prof. Tyndall is quick to perceive the scientific questions which are to be fashionable, so to speak, among the general public. He early saw the tide of interest which was setting toward the ice-formations of Switzerland. He led the general public to appreciate the doctrine of the conservation of force by his admirable treatise on "Heat as a Mode of Motion." He is the pioneer in the modern style of popular scientific lectures, which gives to beauty of experimental illustration a lucid yet imaginative diction. No less ready has he been to perceive the coming ferment in religious matters; and he has dashed gallantly into the combat with a certain Celtic fire, leaving perhaps many unguarded points. It may be that he considers that the religious agitation in Germany has nothing to do with the prerogatives of emperor or pope: but that bigoted religion and science are the true antagonists, and, with his customary insight into the scientific tendencies of the age, he is eager to be the first in the field. There is much in the spirit of protest which the Belfast address breathes that appeals to the mind of every scientific man.

Ministers who are only general readers in science can have no conception of the scientific spirit which comes through investigation. There is a cultivated interest which arises only from familiarity with methods, processes, and instruments. A minister lives apart from the seething turmoil and progress of the scientific world; and, if he should attempt to dispute with innovators, he will meet the same fate as any comparative recluse who attempts to dictate to the world from his retirement.

Nothing leads thinking young men of scientific tendencies to neglect church-going more than wrong-headed and illogical deductions from science by their pastors. They hear the doctrines of Darwin condemned by men who have not carefully read the many treatises for and against evolution, and who have not sound conceptions of the true grounds of the learned authors. The writer once heard a divine vigorously controvert the doctrines of Darwin, and exhaust his resources of invective upon the unfortunate believers in the evolution theories of the present, much to the edification of the regular church-goers, who, for the most part, had never read the books which were criticised, but had a general idea that Darwinism, socialism, and communism, were equally pernicious to the welfare of society. The occupant of the pulpit, upon seeing that he swept his audience with him, elevated himself to his full height and exclaimed, "If they believe that man descended from an ape, let them take a monkey from the Zoological Gardens, and, by a process of natural selection and cultivation, make a man of him. Surely this is not unreasonable to ask!"

I often hear sermons from men who admire the progress of science, yet who do incalculable damage by drawing wide and unwarrantable inferences and conclusions from scientific facts. These inferences are often made by men who are well read in the scientific literature of the day, but who do not regard the limits of scientific generalizations, and take steps which the scientific hearer would not dream of taking. The hearer, knowing how defective the preacher's judgment is in his inferences from science, naturally doubts the clearness of his pastor's judgment on even purely theological points. The attempt to reconcile science and religion is like an endeavor to measure two constantly-expanding scales by comparison with each other. It does not seem to be recognized that a scientific man can have a religion apart from his science: that it is not necessary for him to apply the exact laws of his particular science to his religious convictions, or to test the logic of his belief by the methods which he has found necessary and invaluable in scientific investigations. Many scientific men who are considered atheists are far from being so. It is compatible for a man to be a logical reasoner in an exact science, and yet to refuse to apply the touchstones, which serve him in his science, to his religion. He recognizes that his religious belief is an inherent want of his nature. Strict logicians may laugh at him, and claim that he is inconsistent; he himself feels that his tests fail; he cannot reason; he must receive much on faith. Nothing, therefore, is so disagreeable and demoralizing to the man who is loyal, both to his religion and his science, as to hear the attempts of preachers to reconcile an incomplete knowledge of Nature's laws—for, at the best, we are only on the boundaries of the science of Nature—with the great mystery of revealed religion. It were better that the subject should be left untouched; that the minister should be pronounced not in step with progress, than that he should awaken the spirit of opposition and distrust in the minds of the thinkers on scientific problems.

Such are some of the evils of a superficial exposition of science from the pulpit. If the young student of theology has had a rigid scientific training, it will prove of great advantage to him in the future. Leading minds in the Church recognize that, if the materialism arising from the spread of scientific ideas, received at second hand and fondled until they have deadened religious faith, is to be combated successfully, it must be attacked by men who are not mere superficial readers, who get up their knowledge of science as they would the history of the Reformation. There is a type of character at the present day which is seen in almost every community. The men constituting it, with the most superficial knowledge of science, have their own views upon the causes of natural phenomena. They believe in animal magnetism—in the connection of electricity with every thing that fails to be explained by any other agent. They speculate upon the constitution of suns and comets. Said one of this class to the writer lately : "Do you believe that the sun is heat ? You are wrong if you do. I believe that it is electricity." The minister must deal with this type, with sound knowledge. An omnivorous reader, a village wiseacre in science, may easily have, in these days, a little sect of his own in a community. The minister, therefore, cannot ignore science, if he would reach all hearts. Yet an illogical and incomplete treatment of Nature's laws, and wrong deductions and false applications, will be quickly criticised by men who, however much they like to have hypotheses of their own, are harsh and critical to those of their minister.

Let us see what the training is which is to enable our young divinity students to successfully combat the modern scientific materialism. We shall take the catalogues of four leading divinity schools—the schools at Andover, Harvard University, Yale, and Princeton :

At Andover, the *junior year* is devoted to the study of the Hebrew and Greek Scriptures, systematic theology, homiletics, church history, and elocution ; the *middle year* is devoted to systematic theology, the Hebrew and Greek Scriptures, church history, and elocution ; the *senior year* is devoted to church history, homiletics, Hebrew and Greek Scriptures, pastoral theology, and elocution.

In addition to the regular course of instruction, special courses of lectures are delivered by eminent clergymen on foreign missions, home missions, and Congregationalism.

At the Harvard Divinity School the course consists of the following :

Hebrew Language ; principles of criticism and interpretation ; the literature, canon, and exegesis of the Old and New Testaments ; biblical archæology and geography ; natural religion, and the evidences of revealed religion ; the philosophy of religion ; systematic theology ; philosophical and Christian ethics ; the ethnic religions, and the creeds of Christendom ; ecclesiastical history, and the history of Christian doctrine ; church polity and administration.

We learn, from the prospectus of the Yale Theological School, that "the chief aim of the seminary is to train men to be preachers of the Gospel, and especially such teachers as the present state of the world requires." Its course of study is as follows:

Junior year, encyclopædia and literature of theology, and instruction in Hebrew grammar and philology; exegetical study of the Greek New Testament; mental philosophy, with special reference to the study of theology—also natural theology; the evidences of Christianity, and the inspiration of the Scriptures—also, as incidental to these topics, the various forms of skepticism; *middle year*, systematic theology; general church history; Biblical theology; critical study of the New Testament; American church history; *senior year*, sacred rhetoric and homiletics; pastoral theology; Christian doctrine and on symbolical theology; church polity; lectures in natural theology and moral philosophy; natural philosophy; history; political economy; anatomy and physiology. The undergraduate departments are open to the divinity students, as also are the courses in the Sheffield Scientific School.

The course at Princeton differs in having a department entitled "The Harmony of Science and Revealed Religion," extending through the junior and senior years of the undergraduate department as a required course. "The first year of the course includes the study of natural theology, as connected with the physical sciences which illustrate the being and attributes of the Creator; and of natural religion, as connected with the mental and moral sciences which illustrate the Divine government, future state, and probation." The second part of the course includes a similar defense of revealed religion by the inductive logic, with the study of the miraculous, prophetic, historical, and scientific evidences of Christianity. The third part includes the study of inductive science as connected with revealed religion; the history of their seeming conflicts and alliances; the logic applicable to their relations, and the growing evidences of their harmony as alike involving the promotion of perfect science and the vindication of the Christian religion. The text-books used, in the elementary part of the course, are Paley's "Natural Theology," Butler's "Analogy of Religion and Nature," and Bacon's "Novum Organum;" with frequent lectures upon the topics of which they treat, as well as upon other more recent questions emerging in the different sciences which are in relation with revealed religion.

It will be seen that scarcely any attention is paid to a scientific training, or to methods of scientific thought. The young divinity student who enters any theological school—without a preliminary college education—can know nothing of the great questions upon which he is destined to preach with more or less confidence. The time of study, indeed, may be too short for a scientific course in any divinity school. And it is to be doubted whether general lectures on science, or on scientific methods of thought, illustrated even with the aid of such books as Jevons's "Principles of Science," can do much to enable the young theologian to sufficiently appreciate the attitude of scientific men. Laboratory work will only enable a man to perceive the true scope and limit of science. This laboratory work cannot be undertaken by the young divinity student unless he takes it during a college course, as it is possible to do at Harvard University. An extended scientific training appears to be an impossibility for a young minister; and the most successful sermons seem to the writer, who is both a member of a church and a lover of science, to be those in which argument and logic are laid aside, and simple faith and enthusiasm take their place. A minister cannot expect to meet a scientific man on his own ground, in regard to the scope and bearing of his studies. By his eloquence in denunciation of scientific radicalism he can only hope to carry with him those who are ignorant, and who cling to old traditions. With his present preliminary education a minister cannot influence deep thinkers by any wealth of argument which he may possess. He can only hope to do this by the great power of touching human sympathies which the Bible gives him; by dwelling on the joys and sorrows of man's strange and brief career, and by picturing that hereafter of purity which, we venture to say, no man, even the most short-sighted scientific materialist, ever despairs of.

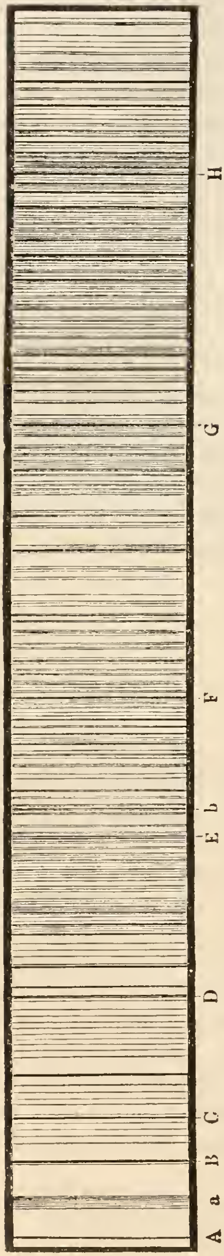
SKETCH OF DR. JOSEPH FRAUNHOFER.[1]

FEW things in the history of science are more interesting than the examples it affords of men devoting themselves with passionate assiduity and untiring persistence to researches which the investigator himself can neither turn to account nor are to be of any ultimate use, and which the public regards as in the last degree frivolous and futile, but the value of which is ultimately and abundantly justified. A man works like a martyr at some obscure and unknown subject, is laughed at and commiserated by his contemporaries, dies, and drops out of memory, until in after-times, in the turns of thought, his results are suddenly invested with a grand interest, and become a passport to their author's immortality. Something like this was the fortune of the subject of the present sketch; he worked in a field which nobody thought of the slightest moment, but he has linked his name forever with one of the most brilliant discoveries of this century.

Joseph von Fraunhofer was born in Straubing, Bavaria, March 6, 1787, of humble parents, and was left an orphan in 1799, at the age

[1] Pronounced *Frown'-ho-fer.*

of eleven years, when he was bound out as apprentice to a glass-cutter in Munich, who was very exacting of him in the way and time of his work. The young apprentice, however, without any instructor, found means, in what little time he had to himself, to make up as well as he could the deficiencies of his education, and made great progress in mathematics, besides getting a knowledge of astronomy. From this station he owed his elevation to an accident when nineteen years old. Working himself out unhurt from an old tumble-down house which fell in on him, he became a sort of neighborhood hero, attracting the attention of some gentlemen of wealth and rank who took an interest in the apprentice whom they found trying to cultivate the sciences in such adverse circumstances. They brought him to the notice of and introduced him to the celebrated Reichenbach, who gave him a place as optician in his great establishment for the construction of mathematical and philosophical instruments at Benedictbaiern, near Munich. He found here ample scope for the exercise of his talents, and could now study optics as a science. He soon distinguished himself by his inventive genius and the skill he displayed in the execution of the processes which he was employed upon. The advantages which he enjoyed he turned to account in making many important experiments in light, and constructing superior instruments for astronomical observations. His discoveries greatly increased the reputation of the establishment, of which he finally became the proprietor himself. He made the best crown-glass for achromatic optical instruments, and invented a heliometer, micrometer, and many other scientific contrivances. The celebrated equatorial telescope in the Russian observatory at Dorpat was made by him. In 1819 he moved his great establishment to Munich, and continued his work there till his death, which occurred June 7, 1826, soon after entering upon the fortieth year of his age. He was a member of the University of Erlangen, and of the Royal Academy of Sciences



FRAUNHOFER'S LINES IN THE SOLAR SPECTRUM.

at Munich. Four years before his death, this Academy appointed him keeper of its Museum of Physics. He had the Order of Civil Merit conferred on him by the King of Bavaria, and received the Order of Danebrog from the King of Denmark.

It was as a scientific optician, not only thoroughly familiar with the theory of the subject, but skillful in the use of instruments, and an accurate and painstaking observer, that Fraunhofer entered upon the exploration of a new phenomenon in the solar spectrum.

It is well known that we are indebted to Sir Isaac Newton for the capital experiment of the decomposition of white light into its constituent color-rays. He passed the beam from an opening in a shutter through a glass prism in a darkened room, and got the image of colors in the order of their refrangibility, forming what is familiarly known as the solar spectrum. But this spectrum is not pure. He used the light from a round hole in the shutter, and the ray, when passing through the prism, gave a series of overlapping images of the aperture, by which the colors of the spectrum were somewhat mixed, and, in consequence of this, there was a peculiar class of effects which he did not recognize. His experiment was made in the year 1675, exactly 200 years ago, and for 127 years his method of forming the spectrum was followed, and no step was taken toward the discovery of the phenomena now to be considered. But, in 1802, Dr. Wollaston, an Englishman, examined the spectrum formed by a narrow opening or slit, and found that instead of being so pure as had always been supposed, it was crossed in various places by fine dark lines. The observation attracted no attention at the time, and was not followed up by himself or others.

These dark lines were afterward rediscovered by Fraunhofer, who became so much interested in them that he made them the subject of careful investigation, and his results were so accurate and complete as to have been universally accepted when published in 1814, and the lines from that time have gone under the name of "Fraunhofer's lines." By means of a telescope he observed the spectrum formed by a fine slit, and found that it was crowded with these fine dark lines; that they varied somewhat in thickness, and were distributed in unequal groups throughout the spectral space. He counted 590, from the red to the violet, and made an accurate map of them, as represented in the preceding figure, designating the most important by the letters of the alphabet, large and small, which are still constantly used in the investigations of spectrum analysis.

To the question, What are these dark lines? no clear answer could be given. Science was not as yet prepared to offer an explanation of their cause. Yet Fraunhofer's mind was not idle in regard to this point, and he speculated with great sagacity in the right direction. Optically, or with reference to figure, the dark lines are simply images of the slit. There are of course no such lines in sunlight, but there is in sunlight that which takes the shape of lines when passed through a narrow opening. The white image from such an opening would of course be a fine white line. If passed through a prism the white line would become a series of colored lines, each point or ray of which would be an image of the slit. If the slit is changed to a cross, then there are crosses in the spectrum. The dark lines, of course, are lines in which light is absent, for darkness is absence of light. There are then certain missing rays in the sunlight that come out in the spectrum as lines of vacancy or breaks in its continuity, and Fraunhofer's lines are all of this kind.

Now, Fraunhofer made the important discovery that the lines of sunlight did not vary when examined at different times. His 590 lines were there, in their exact places, at all times of the day, and at all seasons of the year; the *cause* was therefore probably not in the earth's atmosphere; did not pertain to the earth, and therefore probably existed in the sun. Furthermore, he found that the light from the moon and from Venus gave the same system of dark lines. Fraunhofer saw in Venus-light the double *D* lines; *b* also was seen double, and the relative distance from *D* to *E*, and from *E* to *F*, was the same in the Venus as in the solar spectrum. As this light is reflected from the sun, Fraunhofer was confirmed in the conclusion that these lines are of solar origin.

But he went still further. He made careful and extensive observations of the spectra from the fixed stars, and made the striking discovery that they give groupings of dark lines, which differ from those of the sun and from each other. Some of the stellar lines, however, he showed to be identical with those of the sun. Among the lines of the bright star Procyon he recognized the solar line *D;* and in those of Capella and Betelgueux he found both *D* and *b*. Fraunhofer made also the important observation that the bright-yellow line characteristic of the spectrum of sodium exactly coincided with the double dark solar line *D*. But he could not take a step toward explaining the connection. It was impossible for him to know in what way special rays were cut out or absorbed in the sun and stars, so as to give only darkness, but he got clearly before him the great problem which it is the glory of spectrum analysis to have since resolved.

CORRESPONDENCE.

RETARDATION OF THE EARTH'S ROTATION.

To the Editor of the Popular Science Monthly:

SIR: In the work entitled "Correlation and Conservation of Forces," edited by you, is an article on "Celestial Dynamics," by Dr. J. B. Mayer, in which is considered the subject of the diminution of the velocity of the rotation of the earth, in consequence of the retarding influence of the tidal wave. In the course of this article it is stated (page 297) that "theory and experience agree in the result that the influence of the moon on the rotating earth causes a motion of transition from east to west in both atmosphere and ocean," and that "this motion must continually diminish the rotatory effect of the earth, for want of an opposite and compensating influence."

The result of the retarding force of the waters on the axial motion of the earth is stated, by Dr. Mayer, to be the lengthening of the day $\frac{1}{16}$ of a second in 2,500 years; and, further, that this retarding force will eventually diminish and exhaust the earth's rotatory motion.

The theory of Laplace, that opposite aërial currents are, as to their effects upon the rotation of the globe, as $= 0$, and generally, that there are no forces at work in Nature which do not in Nature find their compensating opposites, is held by Dr. Mayer not to be applicable to the effect of this tidal translation of waters. Nevertheless, he proceeds to demonstrate, in the article on "The Earth's Interior Heat," that the decrease of temperature has been far too great, in the last 2,500 years, to have been without sensible effect in accelerating the velocity of the earth's axial motion. It is there shown that the loss of heat and consequent contraction of the earth's surface, in the time above mentioned, must have had the effect of accelerating the earth's rotatory motion to the extent of counteracting the retarding movement of the tides.

Now, if the results of these forces are equal one to the other, the day remains constant, and the law of Laplace would seem to apply as perfectly in this case as in that of opposing aërial currents.

T. H. S.

CHEYENNE, W. T., *February* 16, 1875.

THE NEST AND EGGS OF THE THISTLE-BIRD.

To the Editor of the Popular Science Monthly:

THE yellow-bird (*Chrysomitris tristis*) is exceedingly abundant throughout New Jersey during eight months of the year, and not at all rare during the winter, when it is seen mostly in loose flocks. For several years I have been perfectly familiar with its manner of nesting, and the appearance of the eggs, etc., and I can give my testimony to the correctness of the statements of Wilson, who says these birds cover the nest "on the outside with pieces of lichen, which they find on the trees and fences." In looking over the first volume of the *American Naturalist*, p. 115, I noticed a statement, made by Dr. T. M. Brewer, that he "never saw one that was ever covered on the outside with lichen;" and, in "North American Birds," vol. i., p. 474, he describes a nest from Wisconsin as *typical*, which, on the exterior, was solely "fine vegetable fibres." Here, in New Jersey, and it was from New Jersey nests (or Pennsylvania) that Wilson took his description, the nests are *invariably* lichen-covered. I believe I am justified in using so positive a term. I know that here, also, two broods are raised. So much for the nests.

I have seen many sets of eggs, probably 200, within ten years, and I know that splotches of yellowish-brown, and occasionally purple, are common on the larger end of the egg; not the rule, perhaps, but *common*, i. e., perhaps thirty per cent. of the eggs laid.

CHARLES C. ABBOTT, M. D.

TRENTON, N. J., *February* 16, 1875.

EDITOR'S TABLE.

THE COMING ECLIPSE.

THERE is little rest for the astronomers. Although their science is the oldest and exactest, and has long since taken its place as one of the most perfected divisions of knowledge, yet there never was a time of greater solicitude in regard to undetermined celestial questions than the present. New problems are presented of transcendent interest, and the progress in the construction of instruments and increasing experience in observation are certain to be rewarded with important extensions of astronomical knowledge.

And there is little rest for the astronomers, not only because of the urgent questions that have recently arisen in their science, but because many of the great phenomena in which they are interested are observable only at critical moments and at rare intervals, and only at a few points upon our planet. The present year will ever be memorable in astronomic annals because of the extensive preparations made to study the transit of Venus; but, while the various parties of observers are returning from the distant stations upon the globe where their observations were made, other expeditions have been fitted out which are traveling again to distant places to observe an eclipse of the sun. This is to take place on the 5th of April; is visible only in the Eastern Hemisphere, and will be mainly observed from stations in the kingdom of Siam. The shadow of total darkness will sweep rapidly along a line of about one hundred miles in breadth, and the time of total obscuration, when all the grand phenomena are displayed, will be but a few seconds more than four minutes. Yet within these fleeting moments many imposing effects are to be accurately noted which will serve as data for resolving the most important questions relating to the constitution of the sun. It was a splendid victory of scientific enterprise when Lockyer and Janssen showed that eclipses could be dispensed with in studying the solar prominences with the spectroscope, and that with their instruments they can at any time sweep round the solar outline, and watch and define those mighty eruptions of gaseous matter which rise to a height of tens and even hundreds of thousands of miles above the photosphere, or light-giving portion of the solar atmosphere; but these observations only heighten the interest of the grand effects which appear when the sun's disk is completely darkened. It is then impressively recognized that this great luminary is very far from being the clear-cut, sharply-defined, luminous globe that it seems to ordinary observation. Its ragged edge is stupendously mountainous, and there moreover stretches away a mighty upper atmosphere, or luminous appendage, called the corona, which can only be examined during the few precious moments of solar darkening.

The corona is therefore now the grand point of attack in a solar eclipse, by telescopic observation, photographic representation, and spectrum analysis; and, with each step of improvement in the construction of instruments, and the facility of their use, we are justified in expecting important accessions to our knowledge of that remarkable phenomenon.

The preparations for observing the April eclipse are suggestive of other considerations which should not be lost sight of. The interests of science are beginning to be recognized throughout the world, and to bring the most diverse nationalities into close relation upon a common platform of sympathetic coöperation. When the different races and nations come into relation in the sphere of politics or religion, antagonisms, discords, jealousies, and hate, are almost inevitably engendered. But, when these are put aside, or kept out of view, and the object to be attained is simply to extend the knowledge of Nature, the better elements of humanity begin to be recognized and asserted. As a striking illustration of this, we have the curious fact that, with reference to the approaching eclipse, it is not the Europeans, but the "King of Siam who has taken the initiative in inviting astronomers to his dominions, and providing for their entertainment while there." On the 9th of last October, his Siamese majesty, through his private secretary, Bhashakarawangse, extended this courtesy to the Royal Astronomical and Royal Societies, and to any astronomers they might accredit to him for the purpose of utilizing the coming opportunity. The English Government sends out an expedition; and an expedition by the French Government goes under the control of M. Janssen. Dr. Hermann Vogel, the eminent Berlin astronomer and photographer, will join the expedition of Janssen at Singapore, and Prof. Tachani will represent the Italian observers.

An intelligent writer in the *Herald*, in the full account which he gives of the preparations for the coming eclipse, thus describes an instrument which has been recently constructed to facilitate observation, and from the use of which much aid is to be expected:

"The siderostat was devised to enable the observer to escape the inconvenience and often the impossibility of changing his position to follow the eye-piece of his telescope, when turned upon the moving sun or star. With the best telescopic mountings and arrangements which have heretofore been employed, the observer is put frequently in the most uncomfortable positions, and his work subjected to those errors irreparable from the nervous handling of his glasses at the exciting and critical moment of the eclipse. The ingenious scientist, Foucault, the perfecter of the siderostat, aimed to give the equatorial the power of making the entire heavens pass before the observer without his having to disturb himself or to displace the instrument. The siderostat, as arranged by him, is, therefore, a telescope fixed horizontally in an invariable position, before which a plane mirror brings successively the various points of the sky. The whole rests on a brass stand, supported by three screws, with two levels and a regulating azimuth movement. The plane mirror is carried by an horizontal axis on the top of two vertical supports, which revolve round a centre, the movement being perfectly effected by small wheels at the foot of the supports. By the employment of the isochronous regulator of Foucault, placed at the foot of the instrument, a motion sensibly equal to the diurnal motion is communicated to the plane mirror, so that the heavenly bodies maintain invariable positions in the field of the horizontal telescope, in front of the apparatus directed toward the mirror. This clock-movement, which has been applied to equatorials, is perfectly regular, and won for its inventor the grand prize in the mechanical arts at the Universal Exhibition of 1867. The apparatus gives perfect steadiness in experiments for measuring the position of spectrum lines and of the displacement of the lines by means of large fixed spectroscopes. Its adaptability has been tested during the recent photographic experiments in connection with the transit of Venus, and with the greatest ease it combines with the observing telescope the apparatus necessary for the work of celestial photography for photometric researches. The complete instrument, telescope and siderostat, placed in the plane of the meridian, may also be regarded as a meridian instrument, so that it is, perhaps, the most powerful weapon of modern astronomy; and, when desired, spectroscopes and photographic apparatus can be attached to the eye-piece of the telescope, of a size even larger than the telescope itself."

THE LITERATURE OF EVOLUTION.

A CORRESPONDENT applied to the editor of the *Nation* asking "for information on books relating to the development or evolution theory, especially for the book 'which is not too partisan or too technical, but gives the facts and reasonings with reference to it on both sides.'" The editor very properly replied that a work giving the facts and arguments on both sides, fairly and fully, is not to be had; and it may be further observed that the reader who is ignorant of the subject, and specifies exactly the work he wants, will be pretty sure not to find it. The choice must be among such books as are obtainable; and the best way to guide the judgment of the inquirer is, to state impartially what resources there are for getting instruction upon the subject, leaving him to decide as to what will best suit his mental requirements.

The first error into which an uninformed reader, who desires to take up the subject of evolution, is liable to fall, is, that he will probably very much under-estimate the task he proposes to undertake. Assuming that he does not want a mere smattering, but an intelligent view of the doctrine, and the nature and extent of its proofs, he must prepare himself for a very considerable amount of intellectual work. For the "evolution theory," whether we consider it established or not, is the most comprehensive doctrine regarding the order of Nature that has ever yet been presented; and, if it be true at all, it is true as a system of principles underlying various and diverse tracts of phenomena. It is a philosophy of the *origination* of things. To the astronomer it is a theory accounting for the origin of stellar and planetary systems; to the geologist it is a doctrine that explains the history of our globe; to the botanist it has interest as throwing light upon the derivation of vegetable forms; and to the zoologist it offers an explanation of the diversities of animal life. The psychologist finds in it a key to the development of mind in all its grades, and the sociologist seeks its aid in tracing the progressive unfolding of the social state. By its most radical implication the "theory of evolution" excludes the view long and universally believed, that in all these spheres the phenomena were "specially created" as we now see them; and it asserts that in all these spheres the present effects have been brought about by gradual changes. The theory of "special creation" being abandoned, a theory of evolution is the inevitable alternative. And if the unity and harmonious interconnections of Nature, of which all science affords the proof, be not an illusion, then the "theory of evolution" must have a basis in the operation of universal principles, and must give rise to a general philosophical method of accounting for the present order of things. When, therefore, a man asks for information concerning the "theory of evolution," he can only be intelligently answered by referring him to the works where such a theory is presented. This, however, is not what the *Nation* does. It directs its correspondent first of all to Darwin's "Origin of Species" for the information he seeks. This is, of course, a great, original, and authoritative book; but it is, nevertheless, a special treatise on one branch of the subject of development, and, so far from making any attempt to expound the general "theory of evolution," there are whole phases of the subject that it does not touch. Nor does it attempt any such analysis of the problem, or resolution into its ultimate principles, as is necessary to the formation of a theory of the subject. Indeed, the very power and popularity of the work are, in a certain sense, due to its restriction, for it is mainly confined to the elucidation of a single principle. "Natural selection" was recognized before Mr. Darwin's time; what he has done is to show how this principle has acted in giving rise to new species from preëxisting species. It is a great thing to have done this, and Mr. Darwin is well entitled to his honors; but none the less is it misleading to cite his book on the "Origin of Species" as an exposition of the "theory of evolution."

Prof. Huxley has evidently had substantially the same question put to him as that directed to the editor of the *Nation*, but he returns to it a very different answer, while there is probably no living man better able to answer it. No one, certainly, knows more thoroughly the nature and extent of Mr. Darwin's contributions to the subject, or has a profounder appreciation of them, than he. And yet, in a lecture before the Royal Institution of Great Britain, Prof. Huxley said, after avowing his belief in the theory of evolution, "the only complete and systematic statement of the doctrine, with which I am acquainted, is that contained in Mr. Herbert Spencer's 'System of Philosophy'—a work which should be carefully studied by all who desire to know whither scientific thought is tending." Nothing can be more explicit or decisive, and, we may add, nothing more candid and just. Knowing perfectly all that Mr. Darwin had done, conversant as he was with the whole literature of the subject, foreign and domestic, he also thoroughly understood the claims of Mr. Spencer's contributions to the question, and his deliberate opinion, given to a critical audience, was, that whoever wanted information relating to the "theory of evolution" could *only* obtain it in a complete and satisfactory form from Mr. Spencer's works.

But the *Nation* thinks differently. It not only does not commend Mr. Spencer's works to readers seeking information on the "theory of evolution," but such readers are tacitly warned against them. Prof. Huxley, who ought to know what science is, recommends all who wish to understand the tendencies of scientific thought, to the study of Spencer's works; the *Nation* objects to Mr. Spencer as an expositor of science. A distinction is drawn between Darwin and Spencer, in which the former is characterized as "scientific and inductive," and the latter as "speculative." But this distinction is altogether groundless. Mr. Spencer's treatment of the problem of evolution is as rigorously inductive as Mr. Darwin's; but, if, to the inductive procedure, Mr. Spencer superadds the deductive, using established truths in an *a priori* way to strengthen and verify his conclusions, we hope that is not to be regarded as a contravention of true scientific method. The implication of the writer that Darwin gives the theory of evolution a firm inductive basis, while Mr. Spencer grounds it upon speculative *a priori* axioms, is as far as possible from being true.

Again, Mr. Spencer's works are contrasted with Darwin's by the writer in the *Nation* as treating of "general speculative philosophy in connection with theology and religion," while Mr. Darwin "nowhere considers scientific theses as either favorable or unfavorable to general philosophical or religious conclusions." Now, let us see what ground there is for this distinction. To a series of exhaustive works on evolution which were expected to run through a dozen volumes, there was prefixed an introductory part of 123 pages, the object of which was to define the sphere of science; and, in doing this, theology and religion were excluded from the discussion. And so this rejection of theology and religion becomes the basis of a charge that Mr. Spencer runs into theology and religion, in contrast to Mr. Darwin, who sticks to inductive science. It seems to be inferred that, because Mr. Spencer has designated his system of thought as a "philosophy," therefore he is chargeable with all the empty and baseless speculation which that term, in its old applications, connotes. But he clearly explains the sense in which he uses the term philosophy. By "philosophy" Mr. Spencer means actual, verifiable, scientific knowledge of the highest degree of generality. His philosophy, in its leading characteristic, is a synthesis or unification of the sciences, and it is no more "speculative" than are the widest truths established in each of the sciences.

Again: the writer in the *Nation* points his contrast by characterizing Mr. Darwin's mental processes as properly Newtonian, while Mr. Spencer's are un-Newtonian. He says that Mr. Spencer has lately put forward the claim that "his method is justified by Newton's precepts and practice;" and he adds that, according to "the leading physicists of the day," this claim is not substantiated. Of this it may be said that Mr. Spencer put forth no such claims until he had been first attacked on this score by the Cambridge mathematicians; and "leading physicists of the day" are not wanting who regard the attack as a conspicuous failure. But, if the case is to go by the force of authority, does the writer in the *Nation* suppose that there are not plenty of "leading physicists of the day" who regard Mr. Darwin's method of reasoning as eminently un-Newtonian?

But to come back to the practical questions put by the correspondent of the *Nation*, we should say with Huxley that, if he wants information on the "theory of evolution" in any complete or adequate shape, he can find it in the works of Spencer more fully and systematically presented than anywhere else. He will find the theory expounded in the first volume of the "Philosophy;" and its biological, psychological, and sociological applications are elaborately presented in the subsequent divisions of the work. In Mr. Fiske's "Cosmic Philosophy" he will also find a masterly exposition of the whole subject, in its broad, philosophical aspects, complete in two volumes.

Darwin's various works are, of course, of great value, but they are voluminous, while Oscar Schmidt's newly published "Doctrine of Descent and Darwinism" is undoubtedly the best summing up of the discussion in the biological field that has yet been published. The works of Haeckel, translations of which will soon be printed, have the reputation of being learned and powerful, but they are limited to the field of zoology, and no more treat of the general "theory of evolution" than do the works of Darwin. The last edition of Lyell's "Principles of Geology" adopts the development theory and applies it to the course of geological life. The strongest books on the other side of the question are probably those of Agassiz, Mivart, and Dawson; and they are, moreover, moderate in size and popular in treatment. There are numerous other books of minor merit, like Lowne's and Henslow's "Prize Essays," but, unless a person has a passion for this kind of literature, and desires to pursue it in all its expressions, it will not be worth while to waste time and money on them when better works are procurable.

INCENTIVES IN EDUCATION.

We last month passed some strictures on the prevailing practice of stimulating educational competition by the offer of money-prizes. The defenders of the policy are, of course, not without their excuses, and the most plausible of them takes this form: "If life is an arena of competition—a struggle for existence—and the school is to be a preparation for life, how can the competitive element be excluded? Life has its prizes to be striven for; a few win and many lose. The school should teach the youth in its charge how to comport themselves under the strains of rivalry that will be put upon them in their subsequent social experience."

To this it may be replied that there are plenty of necessary strife and struggle in the school without superadding to them artificial provocatives. Classing always leads to comparison, and gradation to estimates of capacity which inevitably arouse self-regard, vanity, and the love of approbation.

The very organization of the school, its regular operations, and necessary daily results, are a constant and powerful appeal to the selfishness of the pupils. To be promoted, to beat some one, to outstrip a whole class in the open race, where the results are closely watched, is surely sufficient incentive, without throwing in medals and prizes to intensify the competition. Indeed, the strife, without these additional stimuli, is often far too strong, and requires to be checked by teachers and school-managers, instead of being encouraged and inflamed. Granted that the selfish motives are those by which people are habitually influenced in social life, it is the duty of teachers, and one of the great ends of education, to cultivate another class of motives, and to arouse and strengthen the more generous and disinterested feelings as incitements to action. In its highest purpose, the object of education is the formation of character, and character is the stamp of habitual feeling by which conduct is controlled. The common qualifications of a teacher are, to be able to "hear lessons," and to show children how to read, write, and cipher, but no teacher is fit for his business, in any adequate sense, who cannot discriminate among the gradation of motives by which pupils are influenced, and who cannot call out, exercise, discipline, and invigorate the higher motives that should operate in determining conduct. Undoubtedly we are drifting into a great system of wholesale machine-education, which deals with masses under general inflexible regulations, and in which the individual, as such, virtually disappears. The ambition is rather to drive all the children into the suffocating establishments called schools, and swell the numbers, and thus furnish materials for the National Bureau of Education, that it may flout its astonishing statistics in the face of an admiring world. American education thus takes its place in the category of "big things"—immense prairies, long railroads, universal suffrage, a mighty war, and the other elements of national vanity and boasting which the newspapers never allow us to forget. From this exalted place in the public regard, which our educational system has achieved, it is regarded as an eminent patriotic duty to patronize and encourage it, and so wealthy people can in no way better indicate their love of country, and minister to their own vanity, than by giving here a hundred dollars, and there five hundred, as prizes to be fought for in the schools. All this only aggravates an evil already too strong, and with which, from the very constitution of the schools, it is difficult to cope.

The education that does not recognize the individual and the elements of individuality as of the first importance, and cannot conform itself to their special and peculiar needs, and bring to bear effectually upon the widely-varying personalities with which it has to deal the incitements most suitable to each case, is, just to that degree, imperfect, and fails in the fundamental object of education. Education is a *leading out* of the faculties, and the very word determines the method. It is not a forcing out, a driving out, or a grinding out by machinery, but a process that expressly excludes the compulsive or coercive element—a *leading out*, which implies that the individual material to be acted upon has a nature that must be respected and acted upon in a given way. The preëxisting spontaneous forces of character, varying in their composition in each personality, are to be regarded by the educator, and are to shape his course, or he will fail of his highest object.

We say, then, that, first of all, the teacher should not be meddled with by thrusting in extraneous stimuli to give artificial excitement to the work of the school-room, and we are glad to see some symptoms of reaction against the old and vicious practice. Our education has come to be so much a matter of demagogism and popular flattery that it will not be easy to carry out reform in this particular; but we welcome the indications that here and there appear, of a recognition of the existing evil and the need of its remedy. The following passage, which we have seen quoted from the late annual report of the able State Superintendent of Schools of Illinois, Mr. Newton Blakeman, although perhaps somewhat sanguine, at any rate rings out the truth:

"The era of shams, and cheats, and claptrap, in education, will have gone by. Rewards, and prizes, and other artificial and vicious incentives to study, will no longer be known, and with them the arbitrary, unjust, and preposterous practice of pretending to note a student's intellectual, moral, and deportmental rank and standing by a mechanical system of marks will also be numbered with the discarded rubbish of an obsolete educational dispensation. The hopes that have been crushed, the hearts that have been stung, the irreparable mischief that has been wrought by that puerile and abominable system, should have sent it to the moles and the bats long ago."

Equally encouraging is the action of the New York Board of Education in passing a resolution that hereafter no medals or prizes shall be accepted as awards to the students of the Normal College, except such as may have been previously founded, or from such persons as granted prizes prior to 1873. If this resolution be proper—that is, if the policy abandoned be bad—pray, why not abolish the existing prizes?

LITERARY NOTICES.

The Chemistry of Light and Photography, in its Applications to Art, Science, and Industry. By Dr. Hermann Vogel, Professor in Berlin. 100 Illustrations. Pp. 290. D. Appleton & Co. No. XIV. of the "International Scientific Series."

At the International Convention of Photographers, held in this country a few years ago, Dr. Hermann Vogel, of Berlin, was the distinguished German delegate, and was much honored as one of the most eminent and successful cultivators of the subject in both its scientific and artistic aspects. Perhaps no man in any country was so well prepared to make a thorough presentation of the principles and practice of this beautiful process, and, upon being applied to to write a book upon the subject for the "International Series" he consented, and the volume now before us confirms the wisdom of the application. It is worthy the reputation of the author and the interest of the subject, and is beyond comparison the best popular treatise on the chemistry of light, and the present state of the arts that have grown out of it, that has yet been produced. The history of the efforts, by scientific men, in the early part of the century, to fix and preserve in some way the images formed by light, is familiar to all. Davy and Wedgwood, of England, made the earliest attempts, in 1802, to secure such lasting impressions. Their results, however, were very imperfect, and from time to time the problem was attacked by other chemists, and was finally solved by Nièpce and Daguerre, and the process was given to the world in 1840. In the light of all that has been done in the past thirty-five years, the little pictures of Daguerre, with their "ugly, mirror-like dazzle, which prevented a clear view of them," are now regarded as insignificant, but they were at first contemplated with wonder. When, however, the process was once securely possessed, it was rapidly improved and extended, until it has now become an important element of civilized life. As Dr. Vogel remarks, photography has "spread over almost every branch of human effort and knowledge, and now there is scarcely a single field in the universe of visible phenomena where its productive influence is not felt. It brings before us faithful pictures of remote regions, of strange forms of stratification, of fauna, and of flora; it fixes the transient appearances of solar eclipses; it is of great utility to the astronomer and geographer; it registers the movements of the barometer and thermometer; it has found an alliance with porcelain-painting, with lithography, metal and book typography; it makes the noblest works of art accessible to those of slender means. It may thus be compared to the art of printing, which confers the greatest benefit by multiplying the production of thought, for it conveys an analogous advantage by fixing and multiplying phenomena. But it does more than this. A new science has been called into being by photography, the Chemistry of Light; it has given new conclusions respecting the operations of the vibrating ether of light. It is true that these services, rendered by photography to art and science, are only appreciated by the few. Men of science have in great measure neglected this branch, after the first enthusiasm excited by Daguerre's invention had evaporated; it is only cursorily that physical and chemical matters are treated on in manuals of photography."

The interest of Dr. Vogel's volume is not at all confined to the treatment of that side of the subject which is important to practical operators. It will be equally appreciated by the multitudes of people who are buyers of photographs, and who not only desire to understand the processes by which they are produced, but to know what are the excellences and defects of photographic productions, and how they are to be intelligently criticised. We print a portion of one of Dr. Vogel's chapters upon this branch of the subject.

Scientific London. By Bernard H. Becker. New York: D. Appleton & Company, 1875, 340 pages. Price, $1.75.

Some one has cleverly pointed out the tendency of all Anglo-Saxons to organize themselves into committees with a president, a vice-president, two secretaries, and a treasurer, before they can do any work, great or small, or indeed before they feel ready to deliberate in concert. We are familar enough with this in America, and we are ready enough to laugh at the extreme to which it is carried; but our English brothers, and peculiarly our English scientific brothers, carry this even further than we do.

Witness the list of the meetings of the scientific bodies of London which are announced in *Nature* weekly. It is worth while to transcribe some of the most important names:

The Royal Society, the Royal Institution, the Society of Arts, the Institution of Civil Engineers, the Chemical Society, the Department of Science and Art, the London Institution, the Birkbeck Institute, the Society of Telegraph Engineers, the Museum of Practical Geology, the British Association, the Statistical Society, the Royal Geographical Society—all the foregoing societies are spoken of in Mr. Becker's book, while there yet remain of the important societies—the Mathematical Society, the Society of Antiquaries, the Royal Astronomical Society, the Entomological, the Zoological, the Asiatic, the Meteorological, the Geological, the Linnæan, the Royal Microscopical, the Royal Horticultural, the Royal Botanic Societies, and quite a number of others, hardly less important—the Society of Biblical Archæology, and the Geologists' Association, for example.

This is a curious and a very instructive list. It shows that year by year the specialists in each branch feel obliged to bring themselves closer together in order to keep pace with the advances in their peculiar subject; and it illustrates well the great share which the scientific societies of England have in forwarding and promoting scientific work. There is undoubtedly a great deal of good done by this system, for each of the minor societies has in it several of the great men of the nation, whose influence is thus exerted, not only upon the Royal Society (of which they are, of course, members), but upon a host of younger and less celebrated men who are elevated by the contact.

The system has, too, an injurious effect which is equally apparent: the great men become "scientific popes" in the eyes of their associates, and the ignoring of every thing foreign—the "insularity"—of Englishmen, which has become a byword in ordinary matters, is specially fostered in science, where of all places it is most noxious.

Thus, to an Englishman, *De la Rue* is, and always will be, "the father of celestial photography," notwithstanding Draper and Bond: and it is so in many other cases. But, in spite of this, the great and small societies are a powerful and helpful force in England, and they contain a galaxy of distinguished names, which may well make any country proud.

Mr. Becker in his interesting little book gives us a glance into several of these great societies, or rather he takes us into his club, and, making himself and his reader very comfortable, he proceeds to chat with agreeable frankness about what he has seen, about what interests him, whether it be the theory of isomeric alcohols, or the way the pretty girls of the London audiences are dressed. Once in a while he seems to feel that he is growing trivial, and drawing forth a memorandum he gives a long (and useful) array of facts and figures. But these occasions are rare; he tells his listener very pleasantly what he has seen in the various scientific companies, what he thought, and what he knows about them, what amused him and what bored him. Almost every one will enjoy his easy talk, and almost every one will learn something from his book. His view of science and scientific men is not precisely the highest nor the most dramatic one. Huxley is one of those who have helped "to gild the pill of science," not a strong man earnestly striving for what he thinks the right and true. Tyndall is quite the same—the enthusiasm, the "sacred rage" in them is quite left out; they are simply men in dress-coats who are successful, eminent, and highly to be respected.

The English astronomer Smyth tells us in one of his fascinating books of a visit which he made to Encke at the Berlin Observatory, and he seizes so well the dramatic side of the situation that his reader almost hears, as he did, the astronomical clock ticking off the seconds which but just now belonged to eternity and are lapsed into time.

To Mr. Becker, Encke would have been an eminent observer and astronomer, and the secretary of the Berlin Academy; and his clock would have been in a mahogany case, and would have cost £100 0s. 0d.; but Mr. Becker's account of the Berlin Observatory would have been worth listening to. Indeed, it is hardly fair to object even in the least to the manner of the book, since its pretensions are so modest and its facts and figures so good; and we are sure that all of Mr. Becker's readers will thank him for the quiet enjoyment he gives them in his 340 pages of pleasant talk.

A Practical Treatise on the Gases met with in Coal-Mines. By the late J. J. Atkinson, Government Inspector of Mines of the County of Durham, England. 53 pp. Price 50 cents. New York: D. Van Nostrand.

The author of this little monograph was an authority upon the most complicated questions of ventilation, and the President of the Manchester Geological Society declares it to be "the most useful book of reference yet published on the ventilation of mines."

The discussion is unquestionably of very great interest to all who have the management of mines, or are exposed to danger from ignorance of the nature of the gases that are set free in subterranean explorations. But the little book seems not without interest to others. The laws of atmospheric change, and their relations to life, are general, and the practical problem of ventilation, as we encounter it every day in our dwellings, is by no means simple. There is much information in this little manual relating to the air we breathe, its pressures, movements, vitiations, and various properties, which is of general interest and importance.

Observations of Sun-Spots at Anclam. By Prof. G. Spoerer. With 23 Lithographic Plates. Publications of the (German) Astronomical Society, No. 13. Leipsic, 1874.

We have had occasion to call the attention of our readers, from time to time, to various popular works on the physical condition of the sun ("The Sun," by Proctor, Lockyer's "Solar Physics," etc.), and we now desire to note the appearance of this great work of Dr. Spoerer's, which, with Carrington's "Observations of the Spots on the Sun," forms the basis upon which future theorists must build.

Carrington's accurate observations commenced in November, 1853, and since that time the solar surface has been assiduously observed by Carrington, Spoerer, Wolf, Secchi, De la Rue, and others, in Europe, and by C. H. F. Peters, Winlock, and Langley, in America. Photographic records of the sun-spots have been made in America, in England, and in Russia; and Germany has just established an observatory at Potsdam which will be exclusively occupied with sun-observations.

Carrington's work covered the period 1853–1861, and Spoerer's extended from 1861 to 1871, and was done on much the same plan. He, of course, confirms the discovery by Carrington of the law which declares that the velocity of the rotation of the outer layer of the sun's surface is greatest near the sun's equator and diminishes gradually toward the poles, and he arrives at other conclusions, a few of which we will give, as generally interesting, referring students of astronomy to the original work. It is well known, from the recent observations (since 1853), that Schwabe's discovery is true that the *number* of spots on the sun's disk is governed by some periodic cause which produces a maximum number and a minimum number of spots every eleven years. It is probable that magnetism, rainfall, and temperature, and other terrestrial phenomena, are connected with this period of eleven years, the cause of which is as yet unknown.

Spoerer has discussed the observations of the spots separately for each half (i. e., northern and southern) of the solar disk. He finds (page 137) that the points of maximum and minimum frequency of spots are reached *earlier* in the *southern* hemisphere of the sun. "While the minimum of the year 1856 still lasted in the northern hemisphere, the increase (in the number of spots) had already begun in the southern hemisphere, and had here in 1858 reached a maximum," while in the northern hemisphere the maximum began in 1860. The *mean* heliographic latitude of the spots, however, shows "no characteristic difference between the two hemispheres."

In the eleven-year period (1854–1864) the ratio of the number of spots in the northern hemisphere to the number in the southern was 933 : 1,000; from 1861–1871 this ratio was 976 : 1,000. The spots on the sun give a means of determining the velocity of the sun's rotation, but the determination of this element is complicated by the fact that these spots have a *drift* or proper motion in longitude. Spoerer finds the angle through which the sun rotates in one day to be 14° 16′ nearly, while Carrington determined this element to be 14° 11′; that is, Spoerer fixes the time of the sun's rotation on its axis as 25 days, 5 hours, 37 seconds. This mean value—14° 16′—is, however, subject to change, and Spoerer suggests that further investigations may show that the changes which are known to occur in this value may be found to occur earlier in that hemisphere of the sun which has, at the time, the greatest spotted area. This question it will require *several* eleven-year periods to settle.

It is to be hoped that these most valuable researches will be continued, and that America will contribute her full share to the labor. There is a sure reward awaiting investigators in this field.

The Elevations of Certain Datum-Points on the Great Lakes and Rivers, and in the Rocky Mountains. By James T. Gardner, Geographer (from the Report of the United States Geological and Geographical Survey of the Territories for 1873). Washington: Government Printing-Office, 1875.

In this modest pamphlet of thirty pages Mr. Gardner has made a very valuable step toward utilizing a vast quantity of material which has until now been little employed. Every railroad or canal has been located only after one or two lines of leveling have been run between its terminal points, and a mere glance at a railroad map of the United States will show what an immense collection of data exists for the determination of the altitude of any point on any railroad.

A complete discussion of this has not been attempted, Mr. Gardner's principal object having been to determine the altitude of Denver, in Colorado, above the mean level of the Atlantic Ocean, Denver being the point to which the altitudes determined by the survey of the Territories are referred.

Incidental to this object, results of great interest have been obtained, a few of which will be mentioned. The material for the work was necessarily of the most varied character and of many degrees of accuracy, from the first trial-lines of reconnaissance-surveys to the final releveling of a finished railroad or canal. Great care was necessary in selecting from the reports of chief-engineers and elsewhere the right figures, and in giving proper weights to these when selected. The chief difficulty, however, was in joining the ends of various lines, each referred to separate points.

The author personally visited many of these terminal points, and had new determinations made when necessary. That he has succeeded may be seen from his results for the altitude of Denver, derived from the lines of the Kansas Pacific and Union Pacific Railroads. This altitude is 5,198.97 feet by the Kansas Pacific Railroad surveys, and 5,194.20 feet by the Union Pacific Railroad surveys, a difference of less than *five feet* in lines nearly 2,000 miles long, which were run at different times, by many different engineers.

In the eastern part of the United States there are many opportunities to check such results in places situated on two or more roads, and the examination of a few such checks will serve to give an idea of the agreement to be expected. At Harrisburg, for example, we have two lines of level, one brought by the Coast Survey and the Pennsylvania Railroad from Raritan Bay (175 miles), and the other from Baltimore by the Northern Central Railroad. The first gives 319.91 feet, the second 319.75. This agreement is rather closer than could be expected, and, although the author does not mention it in this connection, it is subject to an uncertainty in the determination of mean tide at Baltimore, noted further on.

The height of the Chicago city directrix above mean tide, as determined by the surveys of the Pennsylvania Railroad and its connections (900 miles), is 585.41 feet; from the surveys of the New York Central Railroad and connections 587.57, and this agreement is perhaps a fair type of what we may expect from surveys conducted with care over long-established railway-lines.

We will adduce one more example, determining the elevation of the mean surface of Lake Erie: the independent results are 573.08, 572.04, 572.67, 570.75, 571.67, and [581.20]. The last determination is rejected on the testimony of the chief-engineer of the railroad from whose surveys it is given.

Mr. Gardner states, as the results of his experience, that most of the errors found are produced by hasty computation and careless combination of results, rather than by imperfect instrumental work. This is shown by his own careful combinations to be the case, since we cannot consider the agreement he has found as fortuitous. He recommends civil-engineers to connect their surveys with the city-directrices and to send a copy of their profiles to the Signal-Office in Washington, so that their careful work may be made of scientific use, by suitable discussion.

As the results of this investigation Mr. Gardner announces that the great lakes and the surrounding country are now recorded 9 feet too low, St. Louis 23 feet too low, Kansas City 100 feet too low, Indianapolis 100 feet too low, and Omaha 31 feet too low.

These corrections rest on various data, and are not all of equal certainty, but they must be accepted for the present. The whole subject must eventually be thoroughly discussed; until it is, this valuable research will be the standard.

Polarization of Light. By William Spottiswoode, M. A., F. R. S., etc. New York: Macmillan, 137 pp. Price $1.00.

The diffusion of Prof. Tyndall's "Lectures on Light" in tens of thousands of copies throughout the United States has awakened a popular interest in even the more abstruse questions connected with that topic. Mr. Spottiswoode's little volume is devoted to the phenomena of polarization, which it discusses in a style adapted for popular comprehension. The method of the book is synthetic—the phenomena of polarization and its different processes are first brought before the mind of the reader in a number of experiments (which are fully illustrated); then the author explains what is meant by the undulatory theory of light. The phenomena of polarization are seen to accommodate themselves so thoroughly to this theory, that a simple approximation of the two is sufficient to prove that the one is the *law* of the other. Having thus coördinated the phenomena, the author considers in separate chapters "Circular Polarization," "Phenomena produced by Mechanical Means," "Atmospheric and other Polarization," "Figures produced by Crystal Plates," and "Composition of Colors by Polarized Light." The subject last named is illustrated by means of two very beautiful chromo-lithograph plates.

What is Music? By Isaac L. Rice, Author of "Analysis and Practice of the Scales." 94 pp. Price 50 cents. New York: D. Appleton & Co.

This is an ingenious essay by a musical professor who not only practises the art, but speculates freely and boldly upon its nature and origin. The theories of music which have been hitherto proposed do not satisfy him, and he is inclined to consider that the ancients were nearer right in their views of the subject than the moderns. The contrast between the ancient and the modern stand-points he takes to be, that the ancients looked upon music cosmically, or considered it a part of Nature, while the moderns are more disposed to regard it as something subjective. The first half of the work is devoted to an exposition of the various theories that have been proposed —Chinese music, Hindoo music, Egyptian, Grecian, Arabic, and Persian theories, and its scholastic interpretations in the middle ages. The doctrines of Euler, Helmholtz, and Herbert Spencer, are reviewed, and with the latter author Mr. Rice takes issue on many of his positions. The latter half of the work is devoted to a presentation of his own views of the subject. His idea seems to be that, as beauty of form or color is a principle of Nature, displayed in space, so music is a principle of beauty in Nature displayed in time. The key to the author's position is given in the following passage:

"Now, *what is music?* The *beautifier of time*, is the simple and categorical answer—an answer, too, from which further answers to all questions springing from the original question may be deduced; an answer that serves as the corner-stone of the fundamental theory of music itself. It is to adorn the ever-moving space of existence that music was generated and the germs of its development were placed within it. In the space of rest, in visible Nature, Nature itself has undertaken the task of beautifying. And there she has lavished beauties untold and unnumbered. Beauty reigns on the mountain and in the valley, on the hill and in the dale. It is present in the gentle grove as well as in the mighty forest. It is in the little brook and in the magnificent ocean. It is in man and woman, in the birds, in the plants—anywhere, everywhere, it meets our eyes, if we will but see. There are beauties of all kinds and degrees, from the sublime to the graceful, from the magnificent to the picturesque. All this has Nature done for space—and to do something similar for time is the grand and holy object of music. The materials of which music is composed exist only in Time, and here we have the explanation of many of the characteristics of music. Time is motion, is life, yet the sure bringer of change, of death. As it is motion, its influence upon us is emotional, agitating; as it constantly tells us of change and death, it awakens the feelings of melancholy within us. Music, as it beautifies the passing moments, yet tells us that they are passing, and consequently it is so prone to cause sadness."

Without indorsing Mr. Rice's views, which seem to us rather fanciful, his little work will be found suggestive, and contains withal much curious information that will interest the lovers of musical literature.

Chemical Examination of Alcoholic Liquors. A Manual of the Constituents of the Distilled Spirits and Fermented Liquors of Commerce, and their Qualitative and Quantitative Determination. By Albert Prescott, Professor of Organic and Applied Chemistry in the University of Michigan. 108 pp. Price $1.50. New York: D. Van Nostrand.

This volume concentrates the rays of the latest chemical science upon the subject of spirituous liquors. The author has nothing to say of the physiological, pathological, or moral effects of alcoholic beverages, but occupies himself simply with the question of their composition, production, constituents, and imitations; and his book being written under no bias, but simply to state the scientific facts, may be taken as entirely trustworthy. Its especial value will be to chemists who may be required to investigate the constituents and the purity of alcoholic liquors.

Elements of Magnetism and Electricity. By John Angell. 172 pp. Price 75 cents. New York: Putnams.

Though the author's purpose is to fit students to "pass in the first class in the elementary stage of the government science examinations" for aspirants to position in the civil service of Great Britain, the work has a value of its own, as being a succinct statement of the sciences of magnetism and electricity.

Principles of Metal-Mining. By J. H. Collins, F. G. S. 150 pp. Price 75 cents. New York: Putnams.

The object of this little work is to convey some elementary knowledge of the principles and facts of mining in a form suitable for the instruction of young miners. It teaches them what to observe, and how to interpret their observations.

The Treatment of Nervous Diseases by Electricity. By Dr. Friedrich Fieber. Translated by George M. Schweig, M. D. 64 pp. Price 75 cents. New York: Putnams.

This little treatise is addressed to the medical profession. It aims to set forth the many advantages of electro-therapy, with a view to popularizing it among medical men.

The Cultivation of Art, and its Relations to Religious Puritanism and Money-Getting. By A. R. Cooper. 48 pp. Price 25 cents. New York: Charles P. Somerby.

A thoughtful, earnest, temperate plea for æsthetic culture.

Antiquity of Christianity. By John Alberger. 61 pp. Price 35 cents. New York: Charles P. Somerby.

This is an attempt to trace the distinctive dogmas of the Christian religion to heathen originals.

PUBLICATIONS RECEIVED.

Astronomical and Meteorological Observations made during the Year 1872 at the United States Naval Observatory. Pp. 550. Washington: Government Printing-Office.

Annual Report of Lieutenant Wheeler's Geographical Explorations for 1874. Pp. 130. Washington: Government Printing-Office.

On the Muridæ. By Dr. Elliott Coues, United States Army. Pp. 28. Philadelphia, 1874.

Invertebrate Fossils collected by Wheeler's Expeditions of 1871, 1872, and 1873. By C. A. White, M. D. Pp. 27. Washington: Government Printing-Office.

Theory of Education in the United States of America, pp. 22; *and* National Bureau of Education, pp. 16. Washington: Government Printing-Office.

Migrants and Sailors in their Relation to the Public Health. By Drs. John M. Woodworth and Heber Smith. Pp. 21. Cambridge: Riverside Press.

Report of the Commissioners of Lunacy to the Commonwealth of Massachusetts (1875). Pp. 79.

A Guide to the Practical Examination of Urine. By James Tyson, M. D. Pp. 182. Price, $1.50. Philadelphia: Lindsay & Blakiston.

Report of the Trustees of the Building-Fund of the Philadelphia Academy of Sciences. Pp. 24.

Prison Association of New York. Thirteenth Annual Report. Pp. 23.

Report upon the Sanitary Qualities of the Sudbury, Mystic, and other River Waters. Pp. 108. Boston, 1874.

Ohio State Medical Society. President's Address (1874). Pp. 16.

Alimentation. By S. A. C. Hamlin, M. D. Pp. 23.

Hand-book of the Kansas Agricultural College. Pp. 124. Manhattan, Kansas, 1874.

Notes on the Natural History of Portions of Montana and Dakota. By J. A. Allen. Pp. 61. Boston, 1874.

Annual Report of the Treasurer of the United States for the Fiscal Year ended June 30, 1874.

The Transmission of Sound by the Atmosphere. By Tyndall. Gigantic Cuttle-Fish. By Saville Kent. Pp. 32. Price, 25 cents. Boston: Estes & Lauriat.

Municipal Law, and its Relation to the Constitution of Man. By R. S. Guernsey. Pp. 11.

Man and Nature. By Dr. Samuel W. Francis. Parts III. and IV. Pp. 28 and 15. Newport, R. I.: C. E. Hammett.

Modern Thought and Ancient Dogmas. Nos. 1 and 2. Pp. 21 and 28. San Francisco, 1875.

MISCELLANY.

Capture of a Herd of Elephants.—A correspondent of *Land and Water* tells of the capture, in the Mysore district, India, of a herd of elephants, numbering forty-nine head. An irrigating canal winds through a dense jungle, at some points approaching a small river, at others stretching away from it into the jungle. In one place a bend of the canal forms, with the river, an inclosure in the shape of a horseshoe, containing about fifteen acres of wooded ground. To this place elephants resort during the monsoon, crossing the canal at three or four points where the banks have become trodden down by constant use. In order to trap the entire herd, two lines of chains were stretched across the river at the ends of the horseshoe, and a trench was dug on the river-bank to cut off escape on that side. The elephants having crossed into the inclosure, the fords were barricaded with cocoa-nut trees, the canal deepened at those places, and two deep trenches cut from the canal to the river. Fires were kept up at night on the banks of the canal. Meanwhile a deep, circular trench was dug, inclosing about an acre of ground, and two parallel trenches were also dug, leading from the horseshoe to this small inclosure. Drop-gates were made to prevent the animals leaving this *keddah* when once they had entered it.

A large force of men were now directed to drive the herd into the *keddah*. The first attempt failed, the elephants stampeding back into the horseshoe after a few of them had entered the inclosure. A second effort was crowned with success. First came a female with her calf; then seven other females, and after a while on came the entire herd with a rush, males, females, and calves, of all sizes, "like a herd of rather large pigs, jostling and pushing one another through the gate-way." When the last was in, down went the gate, and they were all secured. The catching of the elephants one by one was the work of several days. "The men ride in among them on tame beasts, and put ropes round their legs and necks, after which the tame elephants drag them out in spite of all resistance, and they are chained one by one to trees to be trained at leisure. They do not mind the tame elephants mixing with them at all, even with men on their backs, but they object strongly to the men on the ground, who have to put on the ropes. The clever way in which the tame elephants help is wonderful: they move close up to the wild ones, and understand how to put their legs so as to shield the men from all kicks; they take hold of the wild ones' legs and trunks with their own trunks, and are invaluable."

Habits of the Cotton-Worm.—According to Mr. Aug. R. Grote, the cotton-worm dies out every year, with its food-plant, and its next appearance is always the result of immigration. He has observed that the appearance of the worm in the cotton-fields is always heralded by flights of the moth. The worm is always heard of to the southward at first, and never to the northward of any given locality in the cotton-belt. Mr. Grote never could discover any traces of the insect in any stage during the months *preceding* the appearance of the first brood heralded by the moth, and *after* the cotton was above the ground. Hence he concludes that while the cotton-plant is not indigenous to the Southern States (where it becomes an annual) the cotton-worm moth may be esteemed not a denizen but a visitant, brought by various causes to breed in a strange region, and that it naturally dies out in the cotton-belt, unable to suit itself *as yet* to the altered economy of its food-plant and to contend with the changes of our seasons. Possibly in the southern portions of Texas, or in the Floridian peninsula, the cotton-worm may be able to sustain itself during the entire year. Its true home, however, appears to be the West Indies, Mexico, and Brazil, where the cotton-plant is perennial.

Coal in California.—Dr. J. C. Cooper, formerly connected with the State Geological Survey of California, made some interesting remarks at a late meeting of the California Academy of Sciences on the subject of California coal. The frequent reports in the newspapers of discoveries of valuable coal deposits in different parts of the State he characterized as misleading, not more than one in a hundred of such so-called coal-beds having any value whatever. Unlike the true coal of the carboniferous rocks formed from tree-ferns, algæ, and other plants of low organization, that of the Pacific coast contains the remains of coniferous and dicotyledonous trees, and belongs to the cretaceous rocks, or is of even later origin. It is the lignite of geologists. Many of the beds of this material are too thin to work, a thickness of two feet being the minimum that can be economically taken out. For all practical purposes this lignite in many localities is as good as the older coal, but the thinness of most of the beds makes them useless as sources of supply.

How the Amœba takes its Food.—Prof. Leidy has observed an amœba in the act of taking in its food, and, at a recent meeting of the Philadelphia Academy of Sciences, showed that these curious animals, at least in some instances, employ their pseudopods as instruments for capturing the minute creatures on which they prey. It has commonly been supposed that the amœba's food simply sticks to its body and "falls through" into the stomach-sac. Prof. Leidy saw the two pseudopods of an *Amœba princeps* gradually approach, come in contact, and then actually become fused—thus securing between them a flagellate infusorium. The infusorium continued to move back and forth, endeavoring to escape. "At the next moment a delicate film of the entosarc proceeded from the body of the amœba, and gradually extended outwardly, so as to convert the circle of the pseudopods into a complete sac, inclosing the infusorium."

A Fresh-water Sponge.—At a recent meeting of the New Jersey Microscopical Society, at New Brunswick, its Secretary, Prof. Lockwood, exhibited specimens of a fresh-water sponge, discovered by himself in a pond at Port Republic, New Jersey. The sponge grew in masses, covering several square yards of surface, with a thickness varying from an inch to two inches. It has a dichotomous habit of growth, and the sarcode, or sponge-flesh, was of an intensely dark-green color. It seemed quite closely related to the *Spongilla fluviatilis.* Some slides were shown with the spicules cleaned by treatment with boiling nitric acid. With a new lens of low power (seventy-five diameter), just made by George Wale, and of most excellent definition, the silica-spicules were finely brought out. They are cylindrical, curved, and pointed at both ends. They are limited to one form, and are arranged in little fascicles of about twelve spicules in each bundle.

A. Crum Brown on Chemical Theory.—In his address, as President of the Chemical Section of the British Association, Dr. A. Crum Brown defined chemical constitution as the order in which the constituents are united in the compound, and pointed out that the study of chemical changes (composition and decomposition) cannot lead us to a knowledge of the relative position of the atoms. But such a knowledge is required before a real theory of chemistry can be attained, and a knowledge of the intimate structure of matter may be looked for from an examination of the physical properties of substances, and a comparison of these with their chemical constitution. This, he maintained, is truly a branch of chemistry, and the greatest progress in it had been made by chemists, as might be proved by reference to the works of Faraday, Graham, and Andrews. By pursuing this branch, discoveries might be made which would lead to an hypothesis directly connecting chemistry with dynamics, and enabling us to apply mathematics directly to chemistry. The theory of chemistry would then be a particular case of the theory of dynamics. Such a result must be expected by all who believe in the progress of human knowledge and in the consistency of Nature.

Changes attending the Process of Germination.—In the course of their researches on germination, Messrs. Dehérain and Landrin have discovered that, when moist seeds are kept for two or three days in a closed tube above a column of mercury, the volume of air decreases even before carbonic acid has made its appearance. Moist seeds have, therefore, the property of condensing gases after the manner of porous bodies. But no gas can lose the aëriform state without at the same time giving up some of its latent heat; and it is precisely this disengaged heat which raises the temperature of the oxygen to such a degree that it begins to attack the tissues of the seed, and to awaken the life which lay dormant in it. The authors hold the mechanism of germination to be as follows: 1. Softening of the seed-envelopes by water; 2. Penetration of gases and disengagement of heat; 3. Alteration of the principles contained in the seeds by the heated oxygen. A memoir, giving full details on this subject, will shortly appear in the "French Annals of the Natural Sciences."

Marvine's Survey of Western Colorado.—From a letter of a *New York Times* correspondent, we take the following notes of the survey of Western Colorado, by Marvine's division of Hayden's exploring party: The most interesting section visited was the high *mesa* lying near the head of the White River. This mesa is nearly 1,000 miles in extent, and has an average altitude of about 12,000 feet. A large portion of it is a lava-bed, with innumerable lakes scattered over its whole extent. The influence of these lava-beds on the climate of this section is very marked. The party reached the mesa about the middle of September; it was almost enveloped in clouds; there were about four inches of snow, and the thermometer was down to 6°. The clouds lay on the mesa for weeks, though in the valley it was clear. On the east the mesa descends in precipitous slopes to the flats in Egeria Park; on the west the great lava plateau gradually falls and becomes well timbered, chiefly with spruce; the lava-top ceases, and is replaced by the sedimentary rocks rising from beneath it. The White River country, lying north of the mesa, constitutes the Ute Indian Reservation, and is described by Marvine's party as a grand hunting-ground, with game in abundance, plenty of water and timber, and large areas of fertile soil. It is the best portion of Colorado west of the Parks. The country in Egeria Park, east of the mesa, abounded in a great variety of beautiful wild-flowers, and raspberries of rich flavor. Mr. Barber, the botanist of the party, secured a large and rare collection. Toward the western limit of the region explored, excellent coal began to appear, with the promise of much beyond.

Voelcker on the Quality of Milk.—Dr. Voelcker, who holds high rank in England as an agricultural chemist, asserts that, owing to the natural variations in the quality of milk, it is utterly impossible, in all cases, to ascertain whether a small quantity of cream has been removed from milk, or an inconsiderable proportion of water added to it. As the result of his own experience, he states that milk may be considered rich when it contains 12 per cent. of solid matter, of which 3 or 3½ are pure butter. If it contains over 12½ per cent. of solid matter, and has 4 per cent. or more of fat, it is of extra-rich quality. Good milk, of fair average quality, contains from 10½ to 11 per cent. of dry matter, including about 2½ per cent. of pure fat. Poor milk contains 90 per cent. or more of water. If milk is both skimmed and watered, it yields less than 4 per cent. of cream, and its specific gravity is about 1.025. A great many experiments have led the author to the conclusion that, within certain limits, the specific gravity is the most trustworthy indicator of quality. Some of the objections to the use of hydrometers are based on the mistaken opinion that cream is lighter than water. It is lighter than milk, but, compared with water, it is as 1.012, or even 1.019 to 1.000. A low specific gravity thus always indicates a large proportion of water. From sundry observations, it appears that good, pure milk has a specific gravity of 1.030, skimmed milk being a little lighter; and, further, that milk with a specific gravity below 1.025 is either mixed with water, or is naturally very poor. A useful instrument for approximately determining the percentage of cream is a graduated glass tube, at the top of which the cream may be allowed to collect, and its quantity may be read off.

The Royal Society of Great Britain.—The origin of the English Royal Society is related as follows in the "Memoirs of the French Academy." We give the passage as translated in *Nature*: "Full fifty years had elapsed (in 1666) since the learned men who lived in Paris began to meet at the abode of Father Mersenne, who was the friend of the most learned men in Europe, and was pleased to be the centre of their mutual visits. Messieurs Gassendi, Descartes, Hobbes, Roberval, Pascal (father and son), Blondel, and some others, met at this place. The assemblies were more regularly held at M. de Montmort's, Master of Request in Parliament, and afterward at M. Thevenot's. A few foreign visitors to Paris were present at these meetings. . . . It is possible that these Paris assemblies have given birth to several academies in the rest of Europe. However, it is certain that the English gentlemen who created the Royal Society had traveled in France, and had visited at Montmort's and Thevenot's. When they were again in England they held meetings at Oxford, and kept on practising the exercises to which they had been accustomed in France. The rule of Cromwell was beneficial to these meetings. These English gentlemen, secretly attached to their legitimate lord, and unwilling to take any part in public affairs, were very glad to find an occupation which would give them an opportunity of living far from London without being suspected by the Protector. The Society remained in this state up to the time when Charles II., having resumed the kingly office, brought it to London, confirmed it by his royal power, and gave it privileges. So Charles II. rewarded the sciences which had lent an easy pretext for keeping the faith toward him."

Vitality of Seeds.—Two years ago a few peas, in a very dry and hard state, were found in a sarcophagus containing a mummy, in the course of certain excavations going on in Egypt. The idea was conceived of testing the vitality of these peas, buried as they had been for thousands of years. Three of them were planted, which grew and produced enough to cover, in the year following, a considerable field. Some of of the stalks reached a height of more than six feet, and attained a size which was altogether extraordinary, and a strength which rendered them self-supporting. The flowers were white and rose-colored, and of delicious freshness. The pods were grouped on either side of the stalk, in a sort of circular zone toward the top, and not regularly distributed throughout the plant, as in the common pea. It is believed by those who have examined this ancient pea and tested its edible qualities that it belongs to the family of the ordinary pea of our gardens, but that it is a special variety distinguished by the characteristics above mentioned in regard to the form of the stalk and the disposition of the pods.

In corroboration of the fact that seeds will retain their vitality for an indefinite period when embedded deep in the earth, Prof. von Heldreich, of Athens, Greece, states that on the removal of the mass of slag accumulated in working the Laurium silver-mines, some fifteen hundred years ago, a quantity of a species of *glaucium*, or horn-poppy, has made its appearance; and, what is remarkable, it proves to be a new and undescribed species to which the name *Glaucium serpieri* has been given. Prof. Niven, of the Hull Botanic Garden, England, in further corroboration of the same fact, mentions several instances of extraordinary vitality of seeds, from his own observation, and remarks that, "Doubtless the absence of air, an equable and unvarying condition as regards moisture and temperature, and above all the complete neutralization of the physical influence of the sunlight, constitute the means by which Nature exercises a preservative power in seeds as astounding as it is interesting."

To the above might be added the fact so well known to the farmers of Monmouth County, New Jersey, that the green-sand marl sown upon lands almost sterile "brings in white clover" (*Trifolium repens*) where it was not known before.

Recent Observations of the Planet Venus.—Some eight years ago Prof. C. S. Lyman communicated to the *American Journal of Science* a brief notice of some observations made on Venus when near her inferior conjunction in 1866. So far as appears, the planet was then for the first time seen as a very delicate luminous ring. An opportunity of repeating these observations presented itself on the occasion of the recent transit, and Prof. Lyman has another communication upon the subject in the same journal. "On Tuesday, December 8th," he writes, "Venus was again in close proximity to the sun, and the writer had the satisfaction of watching the delicate, silvery ring inclosing her disk, even when the planet was only the sun's semi-diameter from his limb. This was at 4 P. M., or less than five hours before the beginning of the transit. The ring was brightest on the side toward the sun—the crescent proper. On the opposide side the thread of light was duller and of a slightly yellowish tinge. On the northern limb of the planet, some 60° or 80° from the point opposite the sun, the ring for a small space was fainter and apparently narrower than elsewhere. A similar appearance was observed on the same limb in 1866. The morning after the transit the sky was slightly hazy, and the planet could not be found. On the day following (the 10th) the crescent, extending to more than three-quarters of a circle, was seen with beautiful distinctness in the 9-inch equatorial, and on this and two subsequent days measurements were taken with the filar micrometer for the purpose of determining the extent of the cusps, and consequently the horizontal refraction of the atmosphere of the planet. These observations give a mean of 44′.5 as the horizontal refraction of Venus's atmosphere, or about one-quarter greater than that of the earth's. Six measurements of the diameter of the planet on the 10th give 63″.1. Twenty-four on the 11th give 63″.75."

Blondeau on the Causes of Disease.—In the *Moniteur Scientifique* for November there is a very ingenious essay, by Dr. C. Blondeau, on the causes of disease, in which the author endeavors to show that morbid states are always the result of disordered cellular function. His argument is substantially as follows: The cell exists before the organized being, virtually includes it, and survives it after the play of its organs has been arrested. Hence, in order to understand the phenomena of the organization, we must study the cell which, when its functions are not disordered, is the primary cause of life and motion, but, when they are interfered with, of death. During life, every thing depends on the cell—when the animal respires, the cell acts the chief part in that function; when a muscle contracts, it is the muscular element, the cell, that feels the action of heat and causes the muscle to move. The same is to be said of nervous and glandular action. In a word, the life of the organism is simply the resultant of the life of the cells, their individual existence being coördinated to subserve a perfectly definite object. When this coördination is interfered with, we have disease. And hence, if we would reëstablish the equilibrium, we must remove the obstacles which hinder the cell in the discharge of its functions; but to this end we must understand the nature of the agents which so interfere with its functions. These agents are all the poisons, whether organic or inorganic—whether viruses or mineral substances. The remedies to be employed, therefore, are counter-poisons, also derived from these two kingdoms. Innocuous viruses introduced into the animal economy may neutralize the dangerous effects of those which are toxic, just as certain mineral salts may destroy the disease-germ without endangering the life of the patient. Thus the germ of small-pox is neutralized by vaccine virus, and the syphilitic virus by the salts of mercury.

When it has been demonstrated that disease is the result of disordered cell-secretion, then medicine will rest upon a scientific basis. But, so long as we persist in regarding the human body as a mechanism set in motion by the same forces which act upon inorganic substances, we shall never be able, says the author, to explain the action of poisons on the organism. Until it is admitted that the blood is, for the most part, composed of organized living cells, that these cells act the principal part in forming and maintaining all our organs, and that they may undergo modifications which lead to serious maladies, we shall never be able to trace the disturbances occurring in the economy to any certain and definite cause, or to discover the proper remedies.

Tree-Planting in Towns.—The *American Garden* makes an earnest plea for the planting of trees in the streets of cities, as a sanitary measure. Growing plants assimilate the carbon of carbonic acid, discharging its oxygen into the atmosphere. The respiration of men and animals and the consumption of fuel load the atmosphere with carbonic acid, and the only means of destroying that poisonous gas is found in plant-agency. Hence, if the atmosphere of a city were to be inclosed within impermeable walls, and there were no growing plants within the inclosure, the air would quickly become irrespirable. But of course the air is nowhere thus walled about, and hence the deleterious gases it contains are dissipated and carried away by the unceasing movement of the atmosphere to other regions where an abundant vegetation may deprive it of its carbonic acid. Still, there is no doubt that this purification of the air is accelerated by the presence of vegetation in the cities themselves. The writer in the *Garden* asserts that "Paris has now so large a number of parks, and its streets and boulevards are so profusely planted with trees, that the death-rate has been thereby reduced from one in thirty-four as it formerly was, to one in thirty-nine as it now is."

But trees are further of service in shading gutters and road-ways, thus materially retarding and preventing the action of the sun in producing noxious fermentation. Then, too, the roots of the trees take up large quantities of such matters as are washed by the rains into the interstices of the pavements. Besides these direct sanitary benefits, we must also take note of the comfort derived from the shade of the sidewalks. Last, though not least, the beauty of our cities would be greatly enhanced by the planting of trees in the streets. The author recommends the planting of the sunflower on the Harlem flats of this city. By this means the poisonous gases arising from the decaying garbage used for filling these flats would be neutralized far more effectually than by the application of either "injunctions or disinfectants."

Magnetism and the Imagination.—Dr. Volpicelli, in a communication to the French Academy of Sciences, describes certain experiments made by him to determine whether a magnet can have any influence upon persons of nervous constitution. The first person experimented on was a patient of the hospital Santo Espirito, in Rome, whom the sight of a magnet was sufficient to throw into convulsions. Volpicelli brought with him a simple piece of unmagnetized iron; this, however, produced all the effects attributed to the magnet. The second experiment was made on a person similarly affected with nervous disorder. Volpicelli placed a magnet in this person's hand, and soon the super-excitation was such that it had to be taken away. A few days later the subject of this experiment presided at a meeting of scientific men. All unknown to him, magnets had been introduced into his chair, into the drawer of his table, under his feet—in short, all around him. The meeting lasted for two hours, and, at its close, on being asked how he felt, he declared that he was perfectly well. "It appears to me," continues Dr. Volpicelli, "that these two experiments are sufficient to prove that magnetism has no effect upon the nervous system, and that the cause of the effects produced by the presence of a magnet is to be attributed only to the imagination. As I have shown, if we bring one or more powerful magnets near to a patient without his suspecting their presence, no appreciable effect is produced. For the physiologist, the most interesting circumstance connected with these experiments is the diversity of effects produced by the imagination in nervous subjects when they see a magnet, or suppose the presence of one. The diversity of these effects will, perhaps, lead to the discovery of some new truths."

A Lost Species rediscovered.—How sad the idea of the loss of a species! Suppose our robins were reduced to a single living specimen? When inevitable death should come, the going out of that one individual life would be the extinction of its race forever. There is the typical fact of the disappearance of the dodo. And at home we have the equally remarkable fact of the extinction of that noble shore-bird, the great auk. It is now fifty-five years since Major Long's expedition returned from the Rocky Mountains, bringing many unknown forms of life. Of this expedition Thomas Say was chief zoologist. Among the many new species was one especially of the *Cicindela*, or tiger-beetles, those beautiful insects which have always been favorites with the entomologists. Say described, and named it *Cicindela limbata*. At that time the Rocky mountains were almost the *ultima Thule* of Western adventure. The same region now is wellnigh the geographical centre of the West, and has been the field of much good work by naturalists. However, that insect, although most assiduously looked for, was never found, and belief had nearly settled down that Say was in error about his new species, or that the species had become extinct. Unfortunately, Say's collections were all long ago destroyed, and only his published description of the species remained.

In the current number of *Psyche*, E. P. Austin says: "Last summer, while engaged on the survey of the north boundary of Nebraska, I visited one of the numerous hills of drifting sands with which a large part of that section is covered, when I saw a cicindela fly up, which was evidently quite different from any thing I had ever seen before; on following it, it lighted on a steep slope of bare sand, where, after some exertion, I succeeded in capturing it. By going over the sand, I saw others, and during the time that I remained in that vicinity—about an hour—they increased in frequency, a circumstance which I thought due to disturbing them in their hiding-places by trampling the sand."

On his return East, Austin worked the insect out; and lo! it was the long-lost species, *Cicindela limbata* of Say.

The rediscoverer says: "It may appear singular that the species should have remained undetected so long; but owing to its small size and great activity, as well as because it probably is confined to the barren sand-hills, which are not promising regions to collect in, it is evident that, but for its accidental discovery, it might have remained undetected much longer."

Economizing the Heat of Waste Steam.—Mr. Spence lately exhibited in London his plan for the employment of waste steam as a substitute for fuel. This method is founded on a discovery made by the father of the inventor, and announced by him to the British Association in 1869, viz., that steam liberated at atmospheric pressure, and passed into a saline solution having a boiling temperature higher than that of water, raises the solution to its own boiling-point. Thus, as Mr. Spence showed experimentally, if we take a nitrate-of-soda solution, which boils at 250°, and blow into it steam at 212°, the temperature of the solution will be raised to 250°, the steam condensing and yielding its heat. Mr. Spence uses the solution of caustic soda, both on account of its high boiling-point, and because it does not act injuriously upon iron. The exhaust steam will raise this solution to a temperature of 375°, and the heated solution is then circulated through pipes in an ordinary boiler, and its heat is radiated, for the purpose of generating steam in the place of heat derived from fresh fuel. If the boiler is at a pressure of 30 pounds, the solution will leave it at a temperature of 250°, so that 125 degrees of heat would have been yielded to the water. The solution having been to some extent diluted by the condensation of the exhaust steam, its capacity for heat will be correspondingly reduced; and, if steam at 212° were again blown through it, it would not reach the same temperature as before. It is therefore passed into another boiler of ordinary construction, where it takes the place of water, and is concentrated by steam being generated from it; and in this way its capacity for receiving heat is restored.

Mr. Spence maintained that, if, by taking advantage of his father's discovery, a mode of utilizing the large amount of latent heat contained in the steam now thrown into the atmosphere could be brought into practical operation, so that this latent heat could be made to do actual work, the discovery would be one of enormous value, and he announced his intention of speedily trying the experiment on a manufacturing scale.

Reproduction of Burnt Records.—M. Rathelot, an officer of the Paris law-courts, has succeeded, in an ingenious manner, in transcribing a number of the registers which were burnt during the Commune. These registers had remained so long in the fire that each of them seemed to have become an homogeneous block, more like a slab of charcoal than any thing else, and, when an attempt was made to detach a leaf, it fell away into powder. Many scientific men had examined these unpromising black blocks, when M. Rathelot hit upon the following method of operation: In the first place, he cut off the back of the book so as to leave nothing but a mass of leaves, which the fire had caused to adhere to each other. He then steeped the book in water, and afterward exposed it, all wet as it was, to the heat at the mouth of a *calorifère;* the water, as it evaporated, raised the leaves, one by one, and they could be separated, but with extraordinary precautions. Each sheet was then deciphered, and the copy certified by a legal officer. In this way the records of nearly 70,000 official acts have been saved. The appearance of the pages was very curious—the writing appeared of a dull black, while the paper was of a lustrous black, something like velvet decorations on a black-satin ground, so that the entries were not difficult to read.

Sonorous Sand. — There was recently presented to the California Academy of Sciences, by W. R. Frink, of Honolulu, a specimen of "sonorous sand" from the island of Kauai, one of the Hawaiian group. In a letter accompanying the specimen, Mr. Frink states that the bank from which this sand was taken commences at a perpendicular bluff at the southwest end of the island, and extends a mile and a half almost due south, parallel with the beach, which is about 100 yards distant from the sand-bank. The latter is about sixty feet high, and is constantly extending to the south. At the extreme south end, and for half a mile north, if you slap two handfuls of the sand together, a sound is produced like the hooting of an owl. If a person kneels on the steep incline, and then, with the two hands extended and grasping as much sand as possible, slides rapidly down, carrying all the sand he can, the sound accumulates till it is like distant thunder. "But the greatest sound we produced," says Mr. Frink, "was by having one native lie upon his belly, and another take him by the feet and drag him rapidly down the incline. With this experiment the sound was terrific, and could have been heard many hundred yards away."

The sand of Jebel Nagus, a hill lying to the west of the mountain usually called Sinai, in Arabia, possesses similar properties. According to Captain H. S. Palmer, an English traveler, it gives out musical sounds whenever it is set in motion. The sound produced "is neither metallic nor vibratory. It might be compared to the sharpest notes of the Æolian harp, or to the sound caused by forcibly drawing a cork over wet glass. When at the maximum intensity it may be heard at a considerable distance."

Dr. James Blake, of the California Academy of Sciences, has investigated with the microscope the structure of the Kauai sand, and states that the grains are chiefly composed of small portions of coral, and apparently calcareous sponges. They are all more or less perforated with small holes, mostly terminating in blind cavities, which are frequently enlarged in the interior, communicating with the surface by a small opening. The structure of the grains, Dr. Blake thinks, fully explains the reason why sounds are emitted when they are set in motion. The mutual friction causes vibrations in their substance, and consequently in the sides of the cavities; and, these vibrations being communicated to the air in the cavities, the result is sound. There are, in fact, millions upon millions of resonant cavities, each giving out a sound which may well acquire a great volume, and even resemble a peal of thunder. The sand must be dry, however, in order to produce sound; for, when the cavities are filled with water, the grains are incapable of originating vibrations.

Prof. Wurtz on the Order of Nature.—Prof. Ad. Wurtz, in his address as President of the French Association, referred as follows to the ultimate questions of science: "With regard to matter, it is ever and everywhere the same, and the hydrogen of our earth's water we trace in our sun, in Sirius, and in those nebulæ which are still unformed worlds. Everywhere is motion, too; and motion, which appears inseparable from atoms which constitute matter, is the origin of all physical and chemical force. Such is the order of Nature; and the deeper Science searches into her mysteries, the more clearly it evolves the simplicity of the means used, and the infinite diversity of results. Thus, from under the edge of the veil which we are enabled to lift, a glimpse is revealed to us of the harmonious plan of the universe. As for primary causes, they remain beyond the ken of man's mind; they lie within another domain which man's intellect will ever strive to enter and search. So is man constituted, and such he will forever continue. In vain does science reveal to him the physical structure of the universe and the order of its phenomena: he will strive onward and upward in his innate instinctive conviction that things have not within themselves their sufficient cause, their foundation and origin; he is gradually led to subordinate them to a primary cause, a unique and universal God."

Reported Discovery of Living Moas.—A report is published in an Auckland newspaper, of October 3d, of the finding of two live moas at Browning Pass, New Zealand. The story runs that one R. K. M. Smyth, on September 26th, while hunting, saw his dog set off suddenly at a great pace, barking furiously. He followed, and soon saw two large birds, one of gigantic height, the other smaller. Seeing the dog getting the worst of the fight, Smyth ran back and called his mate to assist him. They got a leather rope, and, under shelter of a small patch of bush, got behind the larger bird and roped it at the first cast. He then took a turn round a birch tree with the rope. The large bird did not show fight to any great extent, and the smaller one remained quietly by it. After this they had very little trouble to secure the legs of the large bird, and they left it fastened to the tree two days, the young one making no effort to leave its mother. With the assistance of some shepherds the old bird was taken to the camp, the young one following. The old bird is eight feet high, and the young one five feet. The story needs confirmation: it is almost too good to be true.

How Migration changes Man.—We are indebted to Rev. I. T. Beman for a copy of an address delivered by him on the "Moulding Influences of Migration upon the Human Family," particularly as exhibited in certain Yankee settlements in Southern New Jersey. The author points out the physical differences existing between these Jerseymen and New-Englanders, as follows: "The complexion of the Yankee is blond, that of the Jerseyman dark. The Jerseyman's face is more reposeful than the Yankee's, less variable in expression, and presents a heavier physiognomy. His hair is more abundant, darker, and coarser. The Yankee has smaller jaws, more slender neck, rounder chest and limbs, more arching instep, etc. As regards mental traits, the Jerseyman is slow of thought, the Yankee quick, inventive. Yet these two populations are sprung from one original stock; circumstances have made them unlike. And the same results will be produced again in the descendants of the Vineland immigrants." "Within three generations," says the author, "the essentially *Yankee* character of Vinelanders will disappear, and many peculiarities of our New-Jersey neighbors, somewhat remodeled, will be grafted upon our descendants."

Prof. Marsh on the Lake-Basins of the West.—In a memoir by Prof. O. C. Marsh, on "The Ancient Lake-Basins of the Rocky Mountain Region," published in the *American Journal of Science*, the formation of these basins is traced back to different epochs of Tertiary time on the evidence afforded by the fauna peculiar to each. The oldest of these Tertiary lake-basins are of Eocene age. The first discovered and best known of these Eocene lake-beds is the Green River basin, lying between the Rocky Mountains and the Wasatch range, in the depression now drained by the Green River. The fauna entombed in this Eocene lake indicates a tropical climate—tapiroid mammals, monkeys, crocodiles, lizards, serpents. The author cites, as an example of the Miocene basins, an ancient lake-bed lying north of the Black Hills. The fauna here discovered indicates a climate much less tropical than that of the Eocene lakes, as is seen in the absence of monkeys, and scarcity of reptilian life. At the close of the Miocene a subsidence took place east of the Rocky Mountains. A great Pliocene lake was thus formed directly over the Miocene basin just mentioned, having nearly the same boundaries on the north and west (Black Hills and Rocky Mountains), but extending much farther east, and stretching south nearly to the Gulf of Mexico. The fauna of this lake-basin indicates a warm temperate climate. The more common mammals are a mastodon, rhinoceros, camels, and horses, the latter being especially abundant.

Insect-catching Plants.—Mr. William M. Canby communicates to the *American Naturalist* some observations on the *Drosera filiformis*, or thread-leaved sundew, which confirm and supplement the observations of other naturalists on the manner in which the leaves of that plant capture insects. At 7 A. M. he placed bits of the common house-fly on sundry leaves of the drosera, near their apices, and, twelve hours later, not only had the glandular hairs around bent toward and touched the atoms of fly, but also in every case the leaves themselves had bent over them, the inflection being about 17°. There were other leaves in the vicinity which had themselves captured flies: many of these were much more bent, undoubtedly from having held the prey a longer time. In one case the leaf had curled round the prey so as completely to encircle it.

Extermination of the Thistle.—The Berlin correspondent of *Land and Water* publishes a piece of information that will be welcome to many a farmer. "Who ever knew," says he, "of two plants being so inimical to one another as one to kill the other by a mere touch? This, however, seems to be the case when rape grows near the thistle. If a field is infested by thistles, give it a turn of rapeseed, and this plant will altogether starve, suffocate, and chill the thistle out of existence. A trial was being made with different varieties of rapeseed in square plots, when it was found that the whole ground was full of thistles, and nobody believed in the rape having a fair run. But it had, and as it grew the thistle vanished, faded, turned gray, and dried up as soon as the rape-leaves began to touch it. Other trials were then made in flower-pots and garden-beds, and the thistle always had to give in, and was altogether annihilated, whether old and fully developed, or young and tender."

Food of the Bongos.—The Bongos, a negro tribe on the Upper Nile, are represented by Schweinfurth as being very indiscriminate feeders. Among them rats and field-mice are esteemed delicacies. The pursuit of these animals is a favorite occupation of the children, who tie them together by the tails in dozens, and carry on a lively barter in them among themselves. But a still greater delicacy is cat-flesh. The children place, in the narrow paths through the tall grass of that region, traps of bamboo, with living field-mice for bait. In these they catch cats. The Bongos, indeed, eat meat of all kinds, except human flesh and the flesh of dogs. They make no objection to meat that is in an advanced state of decomposition; it is then more tender, and, besides, is more nourishing, more strengthening than fresh meat. "Whenever I had cattle slaughtered," says Schweinfurth, "I saw my bearers eagerly contending for the half-digested contents of the stomach, after the manner of Esquimaux, whose only supply of vegetable food seems to come from the contents of the reindeer's paunch. They would even strip off the amphistomous worms which literally live in the stomachs of all cattle in this region, and, without more ado, put them raw into their mouths by the handful. After this, it could no longer surprise me to find that the Bongo reckons as game every thing that creeps or crawls, from rats and mice to snakes, from the carrion vulture to the mangy hyena, from the great fat earth-scorpion to the caterpillar, or the winged termite with its oily, mealworm-like body."

NOTES.

Monsieur N. Raüs, connected with the secrétariat of the Brussels Royal Academy of the Sciences, proposes to publish a "Universal Dictionary of Academies, Learned Societies, Observatories, Universities, Museums, Libraries, Botanic Gardens," etc.—a systematic catalogue of all institutions concerned with the progress of science, letters, and the arts. He requests of the officials of such institutions everywhere to send him information about their establishments under the following heads: 1. Title; 2. Date of foundation; 3. Aims; 4. List of officials (titles only); 5. Location, with the exact address; 6. Prizes, etc., offered; 7. Property owned—such as library, archives, museum, laboratories, etc.; 8. Publications—number and class—number of volumes published since foundation—how these publications may be obtained; 9. Any other useful iuformatiou. M. Rauïs's address is "Académie Royale des Sciences, Place du Musée, No. 1, à Bruxelles."

The World's Production and Consumption of Paper.—The following statistics of paper-making are given on the authority of Rudel, of Vienna, Austria: It appears that there are 3,960 paper-manufacturers in the world, employing 80,000 men and 180,000 women, besides the 100,000 employed in the rag-trade; 1,809,000,000 pounds of paper are produced annually. One-half is used in printing, a sixth for writing, and the remainder for packing and for other purposes. The United States averages 17 pounds per head; an Englishman consumes 11½ pounds; a German, 8 pounds; a Frenchman, 7 pounds; an Italian, 3½ pounds; a Spaniard, 1½ pound; and a Russian only 1 pound annually, on an average.

According to Worsaæ, the civilization of the Age of Bronze originated in Asia Minor, and was first adopted in Greeee. From Greece and Hungary it spread over the rest of Europe. From Greece it spread into Italy, Gaul, and Britain; from Hungary, into Northern Germany and Scandinavia.

E. Monsen, C. E., has written a pamphlet entitled "The Sewage Difficulty exploded." "The author," says *Iron*, "cuts the knot of sewage utilization, by regarding sewage as practically useless for agricultural purposes, thus restricting the question to the easiest and most economical method of rendering it innocuous. He puts his opinion in epigrammatic form when he observes that sludge and sewage require a deal of leaving alone. Having removed the insoluble matter or sludge by deposition, and brought the liquid portion into a coudition sufficiently innocuous, he proposes to pass it into the rivers; the sludge he would bury or store in treuches. It will thus, he says, be put out of the way, and cease to be a nuisance."

It is proposed to make the tidal movements in the British Channel available for compressing air to drive the engines used in excavating the Anglo-French Tunnel under the Straits of Dover.

Experiments made by Fleck, of Dresden, on the disinfecting power of chloride of lime, caustic lime, alum, sulphate of iron, and chloralum, show that the last is by far less efficacious than the others. Alum and sulphate of iron are quite as inoffensive and innocuous as chloralum, while at the same time they are more powerful and considerably cheaper.

A new tonic medicine, stimulant to digestion, and having a marked action on the liver, is mentioned in the *Medical Press*. It is called *boldo*, and is obtained from the boldu, a tree which grows in Chili. One gramme of the tincture excites appetite, increases the circulation, and acts on the urine, which gives out the peculiar odor of boldo.

The mode of fertilization of the closed gentian, the flowers of which never open, has long puzzled botanists. The corolla is twisted up so as to leave no opening at the top. The flowers are all nearly erect, with two stigmas considerably above the five anthers. An English observer has seen humble-bees entering these flowers; they pry or untwist the opening with their mouth-organs and legs, and then pop into the barrel-shaped cavity, which they just fill.

Sir Charles Lyell, author of "Principles of Geology," died February 23d. Deceased was born in 1797. At Oxford University he attended Buckland's lectures on geology. The first volume of his "Principles" was published in 1830. The work has reached its twelfth edition in England, and is the principal text-book of geology in that country. Lyell's "Elements" was originally a part of the "Principles." He also wrote "Geological Evidences of the Antiquity of Man." We gave a portrait of Lyell and a sketch of his life in No. II. of the Monthly.

Died, December 31, 1874, Fraucis Kiernan, F. R. S., author of "Anatomical Researches on the Structure of the Liver." He was a native of Ireland, but had lived in England from boyhood. His researches earned for him his Fellowship in the Royal Society, and also the Copley Medal. He took an active part in promoting the establishment of the London University.

It is in contemplation to send out from Germany during the present year an expedition to explore the north-polar region. The expedition is to consist of two steamships, one to explore the east coast of Greenland, the other to advance to the pole. The funds are to be raised by private subscription.

The Highland Agricultural Society of Scotland lately resolved to memorialize the Government in behalf of agricultural education for the working-classes, that the grants of the department shall be declared to cover instruction in chemistry, mechanics, physiology, botany, morphology, and other scientific subjects, when taught in the abstract, in so far as necessary for agriculture; and also to cover instruction given in the principles of agriculture as an applied science, and to place it in the same position as machine-construction, applied mechanics, the principles of mining, and navigation, which are already included in the list of scientific arts toward instruction in which aid is given, and in which examinations are carried out by the department.

The use of aniline colors for tinting candies, syrups, and the like, is condemned by the *Laboratory* on account of their liability to contain arsenic. In twenty-five samples of aniline red or fuchsine, lately analyzed by Dr. Springmühl, only one was found wholly free from this poison, some of the samples containing as much as 6½ per cent. of arsenic. Cases of poisoning by these colors, as thus used, are numerous and well authenticated, and should warn consumers against brightly-colored syrups and confectionery.

According to the *Mining and Scientific Press*, several vessels laden with coal for California were destroyed by fire last year. The cause was undoubtedly spontaneous combustion, heat being generated by the pressure and friction in the hold of the vessel. The "fire-damp" which escapes from coal-mines arises from slow decomposition of the coal at a temperature but little above that of the atmosphere.

The Berlin Academy of Sciences has voted money for the purpose of maintaining in that city a certain number of scientific men, whose only occupation will be the investigation of science, and who will have no other duties to attend to, such as teaching, lecturing, and the like. Prof. Kirchhoff has received and accepted a "call" from the Academy.

On the 18th of January of the present year, there died at Tring, Herts, England, a woman who had attained the extraordinary age of one hundred and eleven years and nine months. She was of pure gipsy descent, and was born in 1763 at Chinnor, Oxfordshire. Her name was Hearne, by marriage Leatherlund. The parish register of Chinnor shows that she was baptized on the 24th of April, 1763.

From July 25, 1775, when Benjamin Franklin was appointed Postmaster-General, until 1799, only letters and newspapers were conveyed by the United States mails. In the latter year it was provided that pamphlets and magazines also might be transported *when convenient;* and not till 1845 was mailable matter strictly defined as including letters, newspapers, and periodicals. The regulations for 1852 admitted bound books not weighing over thirty-two ounces. The act of 1861 admitted maps, engravings, seeds, and cuttings, not weighing over eight ounces, and books not over four pounds. In 1863 a number of miscellaneous articles were declared mailable, and in 1872 it was enacted that this miscellaneous matter should embrace all articles within the prescribed weight (four pounds) which were not liable to injure the mail-bag or the person of any post-office employé. Down to 1852 the post-office was self-sustaining; since that time there has always been an annual deficit, with the exception of the year 1865.

Prof. J. N. Benedict, who has studied the topography of the Adirondack plateau, with a view to determine the probable cost of storing up the surplus waters of that region for the use of the Hudson and other streams, reports that—1. Immense quantities of water can be safely stored at a comparatively low cost on the Upper Hudson, much of which is now worse than lost, as it runs to waste in spring freshets, which in various ways are the cause of much damage; 2. That this excess alone is sufficient to maintain a good depth of water in the main river for one hundred days in the summer. The lakes of the Racquette basin alone are stated to have a capacity more than six times that of the Black River reservoirs, which supply the eastern division of the Erie Canal.

The "Central Ohio Scientific Association" was organized last November, at Urbana, with the following officers: President, Rev. Theodore N. Glover; Vice-President, P. R. Bennett, Jr.; Corresponding Secretary and Curator, Thomas F. Moses, M. D.,; Recording Secretary, William F. Leahy; Treasurer, J. F. Meyer. The Association holds its meetings once a month at Urbana, the county-seat of Champaign County.

The chief of the Manchester Fire Department gives, in a late number of *Science Gossip*, several instances where leaden water-pipes were gnawed through by rats. Two cases are also cited where the rats evidently mistook a gas for a water-pipe, and gnawed through it; on both these occasions damage was done by fire, by the accidental ignition of the escaping gas. Fires have occurred through rats and mice conveying under the flooring oily and fatty rags which have afterward ignited spontaneously. This is supposed to be a common cause of fire in cotton-mills.

At the Vienna Exposition there were exhibited specimens of paper from the bark of the mulberry, from the stinging-nettle, and from potato-stalks. The mulberry-bark used for paper is the bark stripped from twigs after the leaves have been fed to silkworms. In Hungary the nettle is used with rags for making fine sketching and copying paper, and in Bohemia wrapping-paper is made from potato-stalks.

At the beginning of the present year the amount contributed toward the Agassiz monument was $9,000.

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