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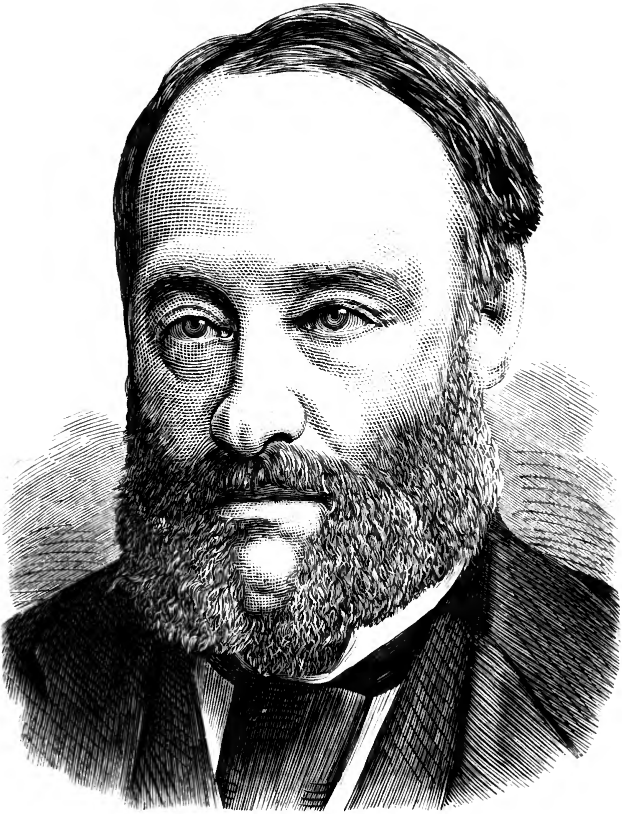

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THE GRAPE PHYLLOXERA.

By CHAS. V. RILEY, M. A., Ph. D.

THIS is an insect which is attracting much attention just now, and which has held a very prominent place in economic entomological literature during the past five years. It has occurred to me that it would not be uninteresting to the many readers of The Popular Science Monthly to have the facts now known about it laid before them in a popular form, and with as little of the nomenclature of science as is consistent with precision. I therefore transmit the following advance matter from the forthcoming sixth "Entomological Report of Missouri," very slightly modified to adapt it to the pages of the Monthly.

To many the term "Phylloxera" is void of meaning, so that it may not be amiss to say, at the outset, that it is a term derived from the Greek (*φύλλον* and *ξηρός*), meaning *withered-leaf*, and founded many years ago,[1] by Boyer de Fonscolombe, to designate a peculiar genus of plant-lice. It was originally erected for a species (*Phylloxera quercus*) quite common in Europe on the under side of oak-leaves, which, in consequence of its punctures, wear a withered appearance. The genus now comprises several species, none of them affecting man's interests except the species under consideration (*vastatrix* Planchon). This, on account of its injurious work, has acquired such prominence that the generic term has come to be used in a broader sense, and to indicate at once the insect and the disease it produces; just as in botany the term *oidium*, though originally referring only to a genus of cryptogamic plants, is now popularly employed to designate the mildew on grape-vines, caused by *Oidium Tuckeri.*

BIBLIOGRAPHICAL.

The first published reference to this insect was made in the year 1856,[2] by Dr. Asa Fitch, the State Entomologist of New York, who

[1] "Annales de la Société Entomologique de France," tome iii., p. 222.

[2] "New York Entomological Reports," vol. i., p. 158.

subsequently described the gall-inhabiting type of it, which I have termed *gallæcola*, in a rather insufficient manner,[1] by the name of *Pemphigus vitifoliæ*. Dr. Fitch knew very little of the insect, as we understand it to-day. It was subsequently treated of by several American authors, and in January, 1867, Dr. Henry Shimer, of Mount Carrol, Ill., proposed for it a new family (*Daktylosphæridæ*),[2] which has not been accepted by homopterists, for the reason that it was founded on characters of no family value.

All these authors referred to the leaf-louse described by Dr. Fitch, and never dreamed that the insect existed in another type on the roots. During the few years following our civil war a serious disease of the Grape-vine began to attract attention in France, and soon caused so much alarm that the Minister of Agriculture and Commerce in that country offered a prize of 20,000 francs for an effectual and practicable remedy; and a special committee was appointed to draw up a programme of conditions, and award the prize if it saw fit so to do.

The disease is known as *pourridie*, or rotting, the roots becoming swollen and bloated, and finally wasting away. There were no end of surmises and theories as to its cause, until Prof. J. E. Planchon, of Montpellier, in July, 1868, announced[3] that it was due to the puncture of a minute insect belonging to the plant-louse family (*Aphididæ*), and bearing a close resemblance to our gall-louse. The insect was subsequently described, by the same author, from the apterous form, under the name of *Rhizaphis vastatrix*, and not till September of the same year[4] when the winged insect was discovered, did he give it the name by which it is now so well known. In January, 1869, Prof. J. O. Westwood, of Oxford, England, announced[5] the receipt of both the gall and root-inhabiting types, from different parts of England and Ireland, and his inability to distinguish between the two. In the same article he announced having received the gall-making type from Hammersmith in 1863, and having described it by the name of *Peritymbia vitisana*, in a notice communicated to the Ashmolean Society of Oxford, in the spring of 1868, which communication was, I believe, never published. In the spring of 1869,[6] M. J. Lichtenstein, of Montpellier, first hazarded the opinion that the Phylloxera, which was attracting so much attention in Europe, was identical with the American insect described by Dr. Fitch. This opinion gave an additional interest to our insect, and I succeeded in 1870, while the Franco-Prussian war was at its highest, and just before the investment of Paris, in establishing the identity of their gall-insect with ours, through correspondence with, and specimens sent to, Dr. V. Signoret, of that city. During

[1] Report, vol. iii., § 117.

[2] Proceedings Academy of Natural Sciences, Philadelphia, January, 1867.

[3] *Messager du Midi*, July 22, 1868.

[4] "Comptes rendus de l'Académie des Sciences de Paris," September 14, 1868.

[5] *Gardeners' Chronicle*, January 30, 1869. [6] "Insectologie Agricole," 1869, p. 189.

the same year I also established the identity of the gall and root-inhabiting types, by showing that in the fall of the year the last brood of gall-lice betake themselves to the roots and hibernate thereon. In 1871 I visited France and studied their insect in the field; and in the fall of that year, after making more extended observations here, I was able to give absolute proof of the identity of the two insects, and to make other discoveries, which not only interested our friends abroad, but were of vital importance to our own grape-growers, especially in the Mississippi Valley. I have given every reason to believe that the failure of the European vine (*Vitis vinifera*) when planted here, the partial failure of many hybrids with the European *vinifera*, and the deterioration and death of many of the more tender-rooted native varieties, are mainly owing to the injurious work of this insidious little root-louse. It had been at its destructive work for years, producing injury the true cause of which was never suspected until the publication of the article in the "Fourth Entomological Report of Missouri." I also showed that some of our native varieties enjoyed relative immunity from the insects' attacks, and urged their use for stocks, as a means of reëstablishing the blighted vineyards of Southern France.

The disease continued to spread in Europe, and became so calamitous in the last-named country that the French Academy of Science appointed a standing Phylloxera Committee. It is also attracting some attention in Portugal, Austria, and Germany, and even in England, where it affects hot-house grapes.

The literature of the subject grew to such vast proportions that, after publishing a biographical review, containing notices and summaries of 484 articles or treatises published during the four years of 1868–'71, MM. Planchon and Lichtenstein gave up the continuance of the work as impracticable.

At the suggestion and with the coöperation of the Société Centrale d'Agriculture de l'Hérault, the French Minister of Agriculture last autumn commissioned Prof. Planchon to visit this country and learn all he could about the insect and its effects on our different vines. Prof. Planchon arrived here the latter part of August and remained over a month, during which time he visited many prominent vineyards in the Eastern States, on Kelley's Island, in Missouri, and in North Carolina. His investigations not only fully corroborated all my previous conclusions regarding the Phylloxera, but gave him a knowledge of the quality of our native grapes and wines which will be very apt to dispel much of the prejudice against them that has so universally possessed his countrymen, who have not followed our recent rapid progress in viticulture and viniculture, but found their opinions on the inferior results which attended the infancy of those industries in America. Such, in brief, is the history of the grape Phylloxera. Let us now take a closer insight into the nature of the insect.

The genus *Phylloxera* is characterized by having three-jointed antennæ, the third or terminal much the longest, and by carrying its wings overlapping flat on the back instead of roof-fashion. It belongs to the whole-winged bugs (*Homoptera*), and osculates between two great families of that sub-order, the plant-lice (*Aphididæ*) on the one hand and the bark-lice (*Coccidæ*) on the other. In the one-jointed tarsus of the larva or newly-hatched louse, and in being always oviparous, it shows its affinities with the latter family; but in the two-jointed tarsus of the more mature individuals, and in all other characters, it is essentially aphididan. "In every department of natural history a species is occasionally found which forms the connecting link between two genera, rendering it doubtful under which genus it should properly be arranged. Under such circumstances the naturalist is obliged to ascertain by careful examination the various predominating characteristics, and finally place it under the genus to which it bears the closest affinity in all its details." So wrote Audubon and Bachman twenty-eight years ago;[1] and what is true of genera is equally true of species, families, and of still higher groups. In the deepest sense all Nature is a whole, and all her multitudinous forms of animal and vegetal life are so closely interlinked, and graduate into each other so insensibly, that in founding divisions on too trivial differences we subvert the objects of classification. Thus, instead of founding a new family for this insect, as Dr. Shimer did, and as there seems a tendency on the part of others to do, it is both more consonant with previous custom, and more sensible in every way, to retain it among the *Aphididæ*.

BIOLOGICAL.

Different Forms which the Insect assumes.—Not the least interesting features in the economy of our Phylloxera are the different phases or forms under which it presents itself. Among these forms are two constant types which have led many to suppose that we have to do with two species. The one type, which I have, for convenience, called *gallæcola*, lives in galls on the leaves; the other, which I have called *radicicola*, on swellings of the roots. The subjoined table will assist to a clear understanding of what follows.

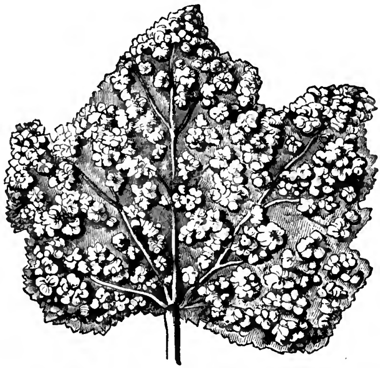
Type 1. *Gallæcola*. (*Vitifoliæ*, Fitch. Fig. 3, *f*, *g*, *h*.)
Type 2. *Radicicola*.—
  a, Degraded or Wingless Form. (Fig. 4, *e*, *f*, *g*.)
  β, Perfect or Winged Form. (Fig. 5, *g*, *h*; Fig. 7, *b*.)

Type Gallæcola or Gall-inhabiting.—The gall or excrescence produced by this insect is simply a fleshy swelling of the under side of the leaf, more or less wrinkled and hairy, with a corresponding depression of the upper side, the margin of the cup being fuzzy, and drawn together so as to form a fimbriated mouth. It is usually cup-shaped, but sometimes greatly elongated or purse-shaped (Fig. 2, *a*, *b*).

[1] "Quadrupeds of North America," vol. i., p. 215.

Soon after the first vine-leaves that put out in the spring have fully expanded, a few scattering galls may be found, mostly on the lower leaves, nearest the ground. These vernal galls are usually large (of the size of an ordinary pea), and the normal green is often blushed with rose where exposed to the light of the sun. On opening one of them (Fig. 3, *d*) we shall find the mother-louse diligently at work sur-

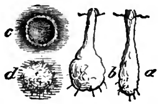
FIG. 1.



LEAF COVERED WITH GALLS.

rounding herself with pale-yellow eggs of an elongate oval form, scarcely .01 inch long, and not quite half as thick (Fig. 3, *c*). She is about .04 inch long, generally spherical in shape, of a dull orange-color, and looks not unlike an immature seed of the common purslane. At times, by the elongation of the abdomen, the shape assumes, more or less perfectly, the pyriform. Her members are all dusky, and so

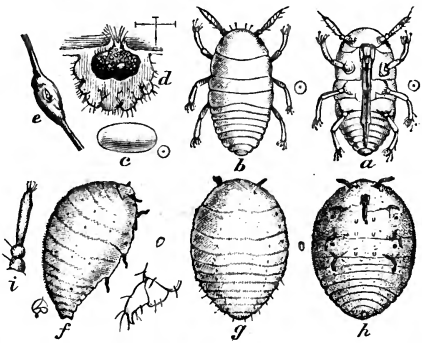
FIG. 2.



a and *b*, elongated galls; *c* and *d*, upper and under side of abortive galls.

short compared to her swollen body, that she appears very clumsy, and undoubtedly would be outside of her gall, which she never has occasion to quit, and which serves her alike as dwelling-house and coffin. The eggs begin to hatch, when six or eight days old, into active little oval, hexapod beings, which differ from their mother in their brighter yellow color and more perfect legs and antennæ, the tarsi being furnished with long, pliant hairs, terminating in a more or less distinct globule. These hairs were called *digituli* by Dr. Shimer, and they lose their globular tips and become more or less worn with age. Issuing from the mouth of the gall, these young lice scatter over the vine, most of them finding their way to the tender terminal leaves, where they settle in the downy bed which the tomentose nature of these leaves affords, and commence pumping up and appropriating the sap. The tongue-sheath is blunt and heavy, but the tongue proper—consisting of three brown, elastic, and wiry filaments, which, united, make so fine a thread as scarcely to be visible with the strongest microscope—is sharp, and easily run under the parenchyma of the leaf. Its puncture causes a curious change in the tissues of the leaf, the

FIG. 8.



TYPE GALLÆCOLA.—*a*, *b*, newly-hatched larva, ventral and dorsal view; *c*, egg; *d*. section of gall; *e*, swelling of tendril; *f*, *g*, *h*, mother gall-louse—lateral, dorsal, and ventral views; *i*, her antenna; *j*, her two-jointed tarsus. Natural sizes indicated at sides.

growth being so stimulated that the under side bulges and thickens, while the down on the upper side increases in a circle around the louse, and finally hides and covers it as it recedes more and more within the deepening cavity. Sometimes the lice are so crowded that two occupy the same gall. If, from the premature death of the louse, or other cause, the gall becomes abortive before being completed, then the circle of thickened down or fuzz enlarges with the expansion of the leaf, and remains (Fig. 2, *c*) to tell the tale of the futile effort. Otherwise, in a few days the gall is formed, and the inheld louse, which, while eating its way into house and home, was also growing apace, begins a parthenogenetic maternity by the deposition of fertile eggs, as her immediate parent had done before. She increases in bulk with pregnancy, and one egg follows another in quick succession, until the gall is crowded. The mother dies and shrivels, and the young, as they hatch, issue and found new galls. This process continues during the summer until the fifth or sixth generation. Every egg brings forth a fertile female, which soon becomes wonderfully prolific. The number of eggs found in a single gall averages about 200; yet it will sometimes reach as many as 500, and, if Dr. Shimer's observations can be relied on, it may even reach 5,000.[1] I have never found any such number myself; but, even supposing there are but five generations during the year, and taking the lowest of the above figures, the immense prolificacy of the species becomes manifest. Small as the animal is, the product of a single year, even at this low estimate, would encircle the earth over thirty times if placed in a continuous line, each individual touching the end of another. Well it is for us that they are not permitted to multiply in this geometrical ratio! Nevertheless, as summer advances, they do frequently become prodigiously multiplied, completely covering the leaves with their galls, and settling on the tendrils, leaf-stalks, and tender branches, where they also form knots and rounded excrescences (Fig. 3, *e*), much resembling those made on the roots. In such a case, the vine loses its leaves prematurely. Usually, however, the natural enemies of the louse seriously reduce its numbers by the time the vine ceases its growth in the fall, and the few remaining lice, finding no more succulent and suitable leaves, seek the roots. Thus, by the end of September, the galls are mostly deserted, and those which are left are almost always infested with mildew (*Botrytis viticola*, Berkely), and eventually turn brown and decay. On the roots, the young lice attach themselves singly or in little groups, and thus hibernate. The male gall-louse has never been seen, and there is every reason to believe that he has no existence. Nor does the female ever acquire wings. Indeed, I cannot lay too much stress on the fact that *gallæcola* occurs only as an agamic and apterous female form. It is but a transient summer state, not at all essential to the perpetuation of the species. I have found it occasionally on all species of the Grape-vine (*vinifera*, *riparia*, *æstivalis*, and *Labrusca*) cultivated in the Eastern and Middle States, and on the wild *Cordifolia;* but it flourishes only on the River-bank grape (*riparia*), and more especially on the Clinton and Taylor, with their close allies. Thus, while legions of the root-inhabiting type (*radicicola*) are overrunning and devastating the vineyards of France, this *gallæcola* is almost unknown there, except on such American varieties as it infests with us. A few of its galls have been found at Sorgues, on a variety called Tinto; and others have been noticed on *vinifera* vines interlocking infested American vines, or have been produced by purposed contact with the young *gallæcola*. Similarly, there are many varieties, especially of *Labrusca*, which, in this country, suffer in the roots, and never show a gall on the leaves.

The precise conditions which determine the production and multiplication of *gallæcola* cannot now, if they ever can, be stated; but it is quite evident that the nature and constitution of the vine are important elements, since such vines as the Herbemont often bear

[1] "Practical Entomologist," vol. i., p. 17.

witness, by their leaves covered with abortive galls, to the futile efforts the lice sometimes persist in making to build in uncongenial places.

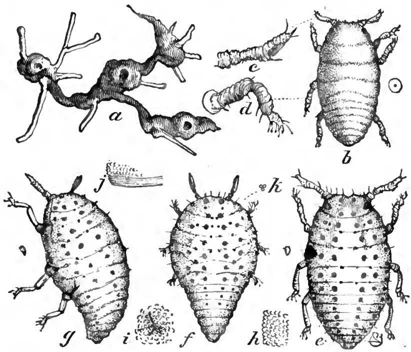
Yet other elements come into play, and nothing strikes the observer as more curious and puzzling than the transitory nature of these galls, and the manner in which they are found—now on one variety, now on another.

I was formerly inclined to believe that *gallæcola* was a necessary phase in the annual cycle of the insect's mutations; in other words, that it was essential to the continuance of the species, and was probably the product of the egg laid by the winged and impregnated female. On this hypothesis I imagined that *gallæcola* was probably the invariable precursor of *radicicola* in an uninfested vineyard, and that, if galls were not allowed to develop in such a vineyard, it would not suffer from root-lice. More extensive experience has satisfied me that the hypothesis is essentially erroneous, and that, while the first galls may sometimes be produced by lice hatched from the few eggs deposited above-ground by the winged female, they are more often formed by young lice hatched on the roots, and which, wandering away from their earthy recesses, are fortunate enough to find suitable leaf conditions. It is barely possible that under certain circumstances, as, for instance, on our wild-vines, where the soil around the roots is hard and compact, *gallæcola* may become more persistent, and pass through all the phases belonging to the species without descending to the roots—the eggs wintering on the ground, or the young under the loose bark, or upon the canes. For a somewhat similar state of things actually takes place with another plant-louse (*Eriosoma pyri*, Fitch), which in the Western United States normally inhabits the roots of our apple-trees, and only exceptionally the branches; while in the moister Atlantic States, and in England and moister parts of Europe, where it was introduced from this country, it normally infests the branches, and more exceptionally the roots. But there are no facts yet known to prove such to be the case with the Grape Phylloxera, even on our wild-vines, and I do not believe that it ever is the case in our cultivated vineyards.

As already indicated, the autumnal individuals of *gallæcola* descend to the roots, and there hibernate. There is every reason to believe also that, throughout the summer, some of the young lice hatched in the galls are passing on to the roots; as, considering their size, they are great travelers, and show a strong predisposition to drop, their natural lightness, as in the case of the young *Cicada*, and of other insects which hatch above but live under ground, enabling them thus to reach the earth with ease and safety. At all events, I know, from experiment, that the young *gallæcola*, if confined to vines on which they do not normally, and perhaps cannot, form galls, will, in the middle of summer, make themselves perfectly at home on the roots.

TYPE RADICICOLA OR ROOT-INHABITING.—We have seen that, in all probability, *gallæcola* exists only in the apterous, shagreened, non-tubercled, fecund female form. *Radicicola*, however, presents itself in two principal forms. The newly-hatched larvæ of this type are undistinguishable, in all essential characters, from those hatched in the galls; but in due time they shed the smooth larval skin, and acquire raised warts or tubercles which at once distinguish them from *gallæcola*. In the development from this point two forms are separable with sufficient ease, one (*a*) of a more dingy greenish-yellow, with more swollen fore-body, and more tapering abdomen; the other (*β*) of a brighter yellow, with the lateral outline more perfectly oval, and with the abdomen more truncated at tip.

FIG. 4.

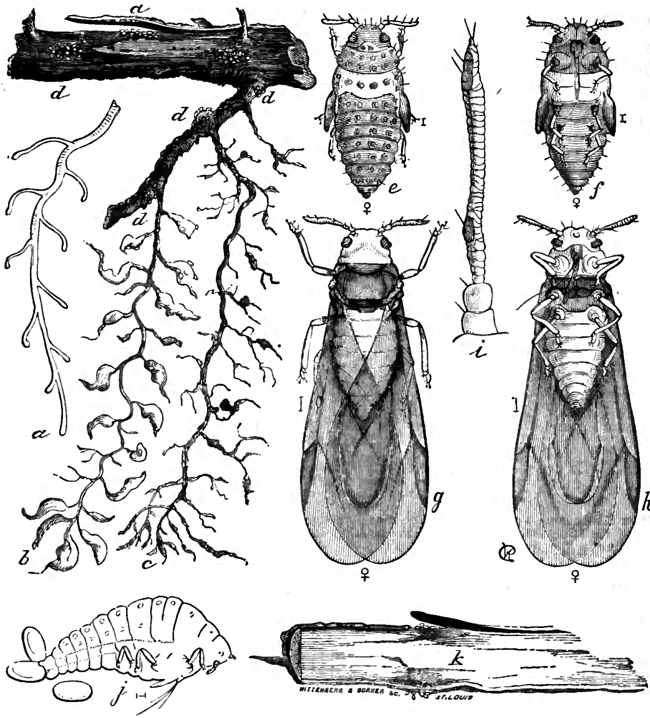


TYPE RADICICOLA.—*a*, roots of Clinton vine, showing relation of swellings to leaf-galls, and power of resisting decomposition; *b*, larva as it appears when hibernating; *c*, *d*, antenna and leg of same; *e*, *f*, *g*, forms of more mature lice.

The first or mother form (Fig. 4, *f*, *g*) is the analogue of *gallæcola*, as it never acquires wings, and is occupied, from adolescence till death, with the laying of eggs, which are less numerous and somewhat larger than those found in the galls. I have counted in the spring as many as 265 eggs in a single cluster, and all evidently from one mother, who was yet very plump and still occupied in laying. As a rule, however, they are less numerous. With pregnancy this form becomes quite tumid and more or less pyriform, and is content to remain with scarcely any motions in the more secluded parts of the roots, such as the creases, sutures, and depressions, which the knots afford. The skin is distinctly shagreened (Fig. 4, *h*), as in *gallæcola*. The warts, though usually quite visible with a good lens, are at other times more or less obsolete, especially on the abdomen. The eyes, which were quite perfect in the larva, become more simple with each moult, until they consist, as in *gallæcola*, of but triple eyelets (Fig. 4, *k*), and, in the general structure, this form becomes more degraded with maturity, wherein it shows the affinity of the species to the *Coccidæ*, the females of which, as they mature, generally lose all trace of the members they possessed when born.

The second or more oval form (Fig. 4, *e*) is destined to become winged. Its tubercles, when once acquired, are always conspicuous;

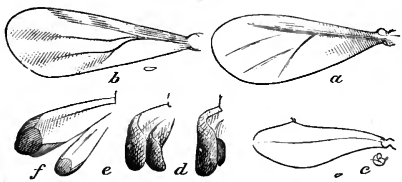
Fig. 5.



Type Radicicola.—*a*, shows a healthy root; *b*, one on which the lice are working, representing the knots and swellings caused by their punctures; *c*, a root that has been deserted by them, and where the rootlets have commenced to decay; *d*, *d*, *d*, show how the lice are found on the larger roots; *e*, female pupa, dorsal view; *f*, same, ventral view; *g*, winged female, dorsal view; *h*, same, ventral view; *i*, magnified antenna of winged insect; *j*, side view of the wingless female, laying eggs on roots; *k*, shows how the punctures of the lice cause the larger roots to rot.

it is more active than the other, and its eyes increase rather than diminish in complexity with age. From the time it is one-third grown, the little dusky wing-pads may be discovered, though less conspicuous than in the pupa state, which is soon after assumed. The pupæ (Fig. 5, *e*, *f*) are still more active, and, after feeding a short time, they make their way to the light of day, crawl over the ground and over the vines, and finally shed their last skin and assume the winged state. In this last moult the tubercled skin splits on the back, and is soon worked off, the body in the winged insect having neither tubercles nor granulations. These winged insects are most abundant in August and September, but may be found as early as the first of July, and until the vines cease growing in the fall. The majority of them are females, with the abdomen large, and more or less elongate. The veins of the front wing are not connected (Fig. 6, *a*), and, by virtue of the large abdomen, the body appears somewhat constricted behind the thorax. From two to five eggs may invariably be found in the abdomen of these, and are easily seen when the insect is held between the light, or mounted in balsam or glycerine. A certain proportion have an entirely different shaped and smaller body, the abdomen being short, contracted, and terminating in a fleshy and dusky penis-like protuberance, the limbs stouter, and the wings proportionally larger and stouter, with

FIG. 6.



PTEROGOSTIC CHARACTERS.—*a*, *b*, different venation of front-wing; *c*, hind-wing; *d*, *e*, *f*, showing development of wings.

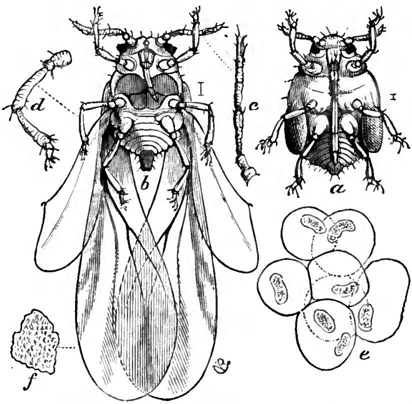
their veins connecting (Fig. 6, *b*). This shorter form (Fig. 7, *b*) never has eggs in the abdomen, but, instead, a number of vesicles (Fig. 7, *e*), containing granulations in sacs. These granulations have much the appearance of spermatozoa, and seem to have a Brownian movement, but are without tails.

This form has been looked upon as the male by myself, Planchon, Lichtenstein, and others. Yet I have never succeeded in witnessing it perform the functions of the male, nor has any one else that I am aware of. The males in all plant-lice are quite rare, and, in the great majority of species, unknown. Where known, this sex bears about the same relation to the female as the shorter and smaller Phylloxera just described does to the larger. These same differences observed in the winged insects obtain in the other species of the genus that are known, and have always been looked upon as sexual. Signoret, an authority on these insects, once so looked upon them,[1] but has lately declared the shorter form to be a female emptied of her eggs. If this be so, then the eggs must be laid before the insect arrives at maturity (a

[1] "Annales de la Société Entomologique de France," 1867, pp. 301, 303.

highly improbable circumstance); for the characteristics which distinguish it are to be noticed in the pupa (Fig. 7, *a*), which is almost as broad as long, with very large wing-pads and strong limbs; while the winged insect does not, as we have seen, carry any eggs. But, whatever the true nature and functions of these problematic and gynandrous individuals, it would seem, from some exceedingly interesting observations lately made by Balbiani,[1] that they cannot be males, if there be any such thing as unity of habit and character among the species of the genus. Balbiani has made the curious discovery, in the annual development of *Phylloxera quercus*, that the winged individuals, which appear in August, fly off to new leaves and deposit their

Fig. 7.



Type Radicicola.—*a*, *b*, pupa and imago of a gynandrous individual, or supposed male; *c*, *d*, its antenna and leg; *e*, vesicles found in abdomen.

unimpregnated eggs, to the number of five to eight. These eggs are of two different sizes, the smaller being readily separated from the larger. They hatch in about a dozen days, the smaller giving birth to males, and the larger to females, which have neither mouth-parts nor digestive organs, and neither grow nor moult after birth. The sole aim of their existence is the reproduction of the species, and they crawl actively about and gather in little multitudes in the crevices and interstices which are afforded them. The male, except in size, seems to differ from the female only in having a small conical tubercle, which serves as sexual organ. Coitus lasts but a few minutes, and the same male may serve several females. Four or five days after birth the female lays a solitary egg, which, increasing somewhat after impregnation, had caused her abdomen to swell and enlarge a little prior to

[1] "Comptes Rendus de l'Académie des Sciences de Paris," 1873, p. 884.

oviposition. Two or three days after this operation the mother dies; but the males live as long again.

This solitary egg, which Balbiani calls the winter-egg, soon takes on a dark color, which indicates its fecundity and distinguishes it from parthenogenetic eggs of both the winged and wingless females. It is surmised that this egg passes the winter to give birth in spring to the form destined to recommence the cycle of development belonging to the species.

These discoveries are truly remarkable, and appear to me all the more so since Balbiani[1] likewise found that the individuals which never become winged attain maturity without laying eggs on the leaves on which they were born, but crawl on to the branches and in the interstices of the old scales at the base of the new year's growth. There they lay a number of eggs, *which are absolutely like those deposited by the winged females, and, like them, produce the sexual individuals, i. e., both males and females.* Now, this does not correspond with what I have seen myself of the species, or with what has been described by others; for the apterous individuals of *quercus* surround themselves with eggs on the leaves where they are born.

M. Max-Cornu has already announced having found a sexual individual, without mouth-parts, of the Grape Phylloxera; and it is quite likely, now that Balbiani has paved the way, that we shall next year have its natural history complete. But whether the Grape Phylloxera produces this fecundated and solitary egg or not, such an egg is neither essential to its winter life, nor to that of an American species (*Phylloxera Rileyi* Lichtenstein), which will be described farther on, and which is, in every respect, very closely allied to the European *quercus*.

While, therefore, there is much yet to learn in the life-history of our Grape Phylloxera, the facts which I have already unequivocally stated, as well as those which I shall now proceed to give, remain indisputable, and do not seem fully to accord with Balbiani's discoveries.

As fall advances the winged individuals become more and more scarce, and as winter sets in only eggs, newly-hatched larvæ, and a few apterous egg-bearing mothers, are seen. These last die and disappear during the winter, which is mostly passed in the larva state, with here and there a few eggs. The larvæ thus hibernating (Fig 4, *b*) become dingy, with the body and limbs more shagreened and the claws and *digituli* less perfect than when first hatched; and, of thousands examined, all bear the same appearance and all are furnished with strong suckers. As soon as the ground thaws and the sap starts in the spring, these young lice work off their winter coat, and, growing apace, commence to deposit eggs. All, without exception, so far as I have seen,[2] become mothers and assume the degraded form (*a*) already described.

[1] *Auctore* Dr. Fr. Cazalis, as reported in the *Messager du Midi*, November 16, 1873.

[2] I have examined thousands in the vineyard in early spring, and other thousands reared artificially in a warm room in winter.

At this season of the year, with the exuberant juices of the plant, the swellings on the roots are large and succulent and the lice plump to repletion. One generation of the mother form (a) follows another—fertility increasing with the increasing heat and luxuriance of summer—until at least the third or fourth has been reached before the winged form (β) makes its appearance in the latter part of June or early in July.

Such are the main features which the development of the insect presents to one who has studied it in the field as well as in the closet.

This polymorphism, which at first strikes us as singular, is quite common among plant-lice, and many curious instances of still more striking character might be given. Even the differences themselves, between *gallœcola* and *radicicola* are more apparent than real. Individuals of the latter are often met with, which, in the comparative obsoleteness of their tubercles, are almost undistinguishable from the former; and the tubercles, like many other purely dermal appurtenances, are of an evanescent and unimportant character. Many insect larvæ, which are normally granulated with papillæ, not unfrequently have these more or less obsolete, and at some stages of growth have the skin absolutely smooth. The same thing holds true of tubercles, which, as in the case of the Imported Currant-worm (*Nematus ventricosus* Klug), are often completely cast off at a moult. In *Phylloxera* they are very variable in size, as we shall see, in *Rileyi;* and in *quercus*, according to several reliable authors, the tubercles which are characteristic of the species in Southern France are entirely wanting around Paris. If we carefully study them in *vastatrix* we shall find that they consist of points where the granulated skin is gathered around a fleshy hair in little rugosities, and becomes darker (Fig. 4, *i*). They do not occur in the newly-hatched larva, are not visible immediately after each moult, and are lost again in the winged individuals. In the form *gallœcola* we shall find, upon careful examination, especially of the exuvia, that, as Max-Cornu has shown, there are rows of these short hairs, scarcely extending beyond the natural granulations and corresponding to those on the tubercles of *radicicola.* These hairs are more visible on the younger and smoother lice, after the first moult; and they are sometimes so stout, particularly on the abdomen, as to remind one of those on *Rileyi*, to be described. The ventral characteristics of the two types are identical.

Since I proved, in 1870, the absolute identity of these two types by showing that the gall-lice become root-lice, the fact has been repeatedly substantiated by different observers. Yet, strange to say, no one has heretofore succeeded in making gall-lice of the young hatched on the roots, though I formerly supposed that Signoret had done so. It is, therefore, with much satisfaction that I record the fact of having succeeded this winter in obtaining galls on a young Clinton vine from young *radicicola*, and of thus establishing beyond peradventure the specific interrelation and identity of the two types. I make this announcement with all the more pleasure, that for three years past, both on vines growing out-doors and in pots in-doors, I had in vain attempted to obtain the same result.

PRACTICAL CONSIDERATIONS.

THE MORE MANIFEST AND EXTERNAL EFFECTS OF THE PHYLLOXERA DISEASE.—The result which follows the puncture of the root-louse is an abnormal swelling, differing in form according to the particular part and texture of the root. These swellings, which are generally commenced at the tips of the rootlets, where there is excess of plasmatic and albuminous matter,[1] eventually rot, and the lice forsake them and betake themselves to fresh ones—the living tissue being necessary to the existence of this as of all plant-lice. The decay affects the parts adjacent to the swellings, and on the more fibrous roots cuts off the supply of sap to all parts beyond. As these last decompose, the lice congregate on the larger ones, until at last the root-system literally wastes away.

During the first year of attack there are scarcely any outward manifestations of disease, though the fibrous roots, if examined, will be found covered with nodosities, particularly in the latter part of the growing season. The disease is then in its incipient stage. The second year all these fibrous roots vanish, and the lice not only prevent the formation of new ones, but, as just stated, settle on the larger roots, which they injure by causing hypertrophy of the parts punctured, which also eventually become disorganized and rot. At this stage the outward symptoms of the disease first become manifest, in a sickly, yellowish appearance of the leaf and a reduced growth of cane. As the roots continue to decay, these symptoms become more acute, until by about the third year the vine dies. Such is the course of the malady on vines of the species *vinifera*, when circumstances are favorable to the increase of the pest. When the vine is about dying it is generally impossible to discover the cause of the death, the lice, which had been so numerous the first and second years of invasion, having left for fresh pasturage.

MODE OF SPREADING.—The gall-lice can only spread by traveling, when newly hatched, from one vine to another; and, if this slow mode of progression were the only one which the species is capable of, the disease would be comparatively harmless. The root-lice, however, not only travel underground along the interlocking roots of adjacent vines, but crawl actively over the surface of the ground, or wing their way from vine to vine, and from vineyard to vineyard. Doubts have repeatedly been expressed by European writers as to the power

[1] For a very minute and careful study of the pathological characteristics of these swellings the reader may refer to Max-Cornu's excellent papers in the *Comptes Rendus*, for 1873, of the Paris Académie des Sciences.

of such a delicate and frail-winged fly to traverse the air to any great distance. "On a calm, clear day, the latter part of last June, it was my fortune to witness a closely-allied species (*Phylloxera caryæfoliæ* Fitch), of the same size and proportions, swarming on the wing to such an extent that to look against the sun revealed them as a myriad silver specula. They settled on my clothing by dozens, and any substance in the vicinity that was the least sticky was covered with them. With such a sight before one's eyes, and with full knowledge of the prolificacy of these lice, it required no effort to understand the fearful rapidity at which the Phylloxera disease has spread in France, or the epidemic nature it has assumed. Imagine such swarms, mostly composed of egg-bearing females, slowly drifting, or more rapidly blown, from vineyard to vineyard; imagine them settling upon the vines and depositing their eggs, which give birth to fecund females, whose progeny in five generations, and probably in a single season, may be numbered by billions, and you have a plague (should there be no conditions to prevent that increase) which, though almost invisible and easily unnoticed, may become as blasting as the plagues of Egypt."[1]

Since the above-quoted passage was written, I have fully proved the same ability to fly in the winged grape-root lice, and am satisfied that they can sustain flight for a considerable time under favorable conditions, and, with the assistance of the wind, they may be wafted to great distances. These winged females are much more numerous in the fall of the year than has been supposed by entomologists. Wherever they settle, the few eggs which each carries are sufficient to perpetuate the species, and thus spread the disease, which, in the fullest sense, may be called contagious. Whether in a state of nature these winged females show a preference for any one part of the vine in the consignment of their eggs, is not yet known. It is quite certain, however, that they do not reënter the ground. Neither do we know whether—in the light of Balbiani's discoveries regarding the European Oak Phylloxera—the young hatching from these eggs produce the diminutive sexual individuals already described. In confinement I have had such eggs deposited both on the leaves and on the buds, and from the preference which, in ovipositing, these aërial mothers showed for little balls of cotton placed in the corners of their cages, I infer that the more tomentose portions of the vine, such as the bud, or the base of a leaf-stem, furnish the most appropriate and desirable *nidi*. On this hypothesis it is quite possible for the insect to be introduced from vineyard to vineyard, or from country to country, as well upon cuttings as upon roots.

[1] "Entomological Report of Missouri," vol. v., pp. 72, 73.

THE LIMITS OF OUR KNOWLEDGE OF NATURE.

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TRANSLATED FROM THE GERMAN, BY J. FITZGERALD, A. M.

JUST as a world-conqueror of ancient times, as he halts for a day in the midst of his victorious career, might long to see the boundaries of the vast territories he has subjugated more clearly defined, so that here he may levy tribute of some nation hitherto exempt, or that there he may discern some natural barrier that cannot be overcome by his horsemen, and which constitutes the true limit of his power, in like manner it will not be out of place, if Natural Science, the world-conqueror of our times, resting as on a festive occasion from her labor, should strive to define the true boundaries of her immense domain. And this undertaking I hold to be all the more legitimate, because I believe there exist two widely-diffused errors with regard to the limits of natural science, and because I think it possible that from the study of such a question, despite its apparent triviality, some advantage might be derived even by those who do not at all share in the errors of which I speak.

Hence I propose to investigate the limits of natural science; and first I must say what natural science is.

Natural science—or, more definitely, knowledge of the physical world with the aid of and in the sense of theoretical natural science—means the reduction of all change in the physical world to movements of atoms produced independently of time by their central forces; or, in other words, natural science is the resolution of natural processes into the mechanics of atoms. It is a fact of psychological experience that, where such a resolution is practicable, our desire of tracing things back to their causes is provisionally satisfied. The propositions of mechanics are mathematically presentable, and have in themselves the same apodictic certainty as the propositions of mathematics. As the changes of the physical world are reduced to a constant sum of potential and kinetic energy, which is inseparable from a constant quantity of matter, there remains in these changes themselves nothing further that needs explanation.

What Kant says in the introduction to his "Metaphysical Elements of Natural Science," viz., that "in each special natural science the amount of science, properly so called, is equal to the amount of mathematics it contains"—must, therefore, be further narrowed down, and instead of mathematics we must read atomic mechanics. Plainly this

[1] An Address delivered at the Forty-fifth Congress of German Naturalists and Physicians at Leipsic.

was Kant's own meaning, when he withheld from chemistry the title of science, and relegated it among *experimental* sciences. It is not a little noteworthy that in our own times chemistry, being forced, by the discovery of the doctrine of substitution, to surrender electro-chemical dualism, has been apparently still further removed from the grade of a science, in this sense of the word.

If we were to suppose all changes in the physical world resolved into atomic motions, produced by constant central forces, then we should know the universe scientifically. The condition of the world at any given moment would then appear to be the direct result of its condition in the preceding moment, and the direct cause of its condition in the subsequent moment. Law and chance would be only different names for mechanical necessity. Nay, we may conceive of a degree of natural science wherein the whole process of the universe might be represented by one mathematical formula, by one infinite system of simultaneous differential equations, which should give the location, the direction of movement, and the velocity, of each atom in the universe at each instant. "A mind," says Laplace, "which at a given instant should know all the forces acting in Nature, as also the respective situation of the beiugs of which it consists, provided its powers were sufficiently vast to analyze all these data, could embrace in one formula the movements of the largest bodies in the universe, and those of the smallest atom; nothing would be uncertain for such a mind, and the future, like the past, would be present to its eyes. The human intellect offers, in the perfection to which it has brought astronomy, a faint idea of what such a mind would be."

Indeed, just as in lunar equations the astronomer need give but a negative value to time, in order to determine whether, when Pericles embarked for Epidaurus, the sun was eclipsed for the Piræus, so could the mind imagined by Laplace, by suitable application of its universal formula, tell us who was the Man in the Iron Mask, or how the President was lost. As the astronomer foretells the day whereon years hence a comet emerges again out of the depths of space into the heavens, so could that mind by its equations determine the day whereon the Greek cross shall glitter from the mosque of St. Sophia, or when England shall have consumed the last of her coals. If in his universal formula he set down $t=-\infty$, he could discover the mysterious primeval condition of all things. He would in the boundless space see matter already in motion, or unequally distributed, for, were the distribution equable, there could never be disturbance of equilibrium. Suppose he lets t grow *ad infinitum* in the positive sense, then he could tell whether Carnot's theorem threatens the universe with icy immobility in finite or only in infinite time. For such a mind the hairs of our heads would be numbered, and without his knowledge no sparrow could fall to the ground. Being a seer expert both in the past and the future, for him, as D'Alembert, in the Introduction to the Encyclopædia, expressed it, giving utterance to the germ of Laplace's thought, "the universe would be one single fact and one great truth."

In Leibnitz, too, we find Laplace's thought, and even better developed in some measure than in Laplace himself, inasmuch as Leibnitz conceives of this mind as being endowed with senses and with technical powers of corresponding perfection. Bayle brought against the doctrine of Preëstablished Harmony the objection that it supposes the human body to be like a vessel that makes for its harbor by means of its own forces; Leibnitz replied that this is not so impossible as Bayle holds it to be. "There is no doubt," says he, "that a man might construct a machine that could for some time move about in a city, and turn accurately at certain street-corners. An incomparably more perfect, though still finite mind, might foresee and obviate an incomparably greater number of obstacles. So true is this, that if the world is, as some suppose, only a compound of a finite number of atoms, which move in accordance with the laws of mechanics, it is certain that a finite mind might be elevated sufficiently to comprehend and to foresee with mathematical certitude whatsoever is to occur therein within a given time. And thus this mind could not only construct a ship capable of making a given port by itself, provided the proper force and direction were supplied, but it could even construct a body capable of imitating the actions of man."

It need not be said that the human mind will ever remain very remote from this degree of acquaintance with Nature. To show how far we are from even the beginnings of such knowledge, we need but make one observation. Before our differential equations could be brought into the universal formula, all natural facts would have to be reduced to the motions of a substantially undifferentiated and consequently property-less substratum of what appears to us as heterogeneous matter: in other words, all quality would have to be explained by the arrangement and the motion of this substratum.

This is entirely in accord with what we know of the senses. It is universally conceded that the sense-organs and the sense-nerves carry to their appropriate cerebral regions, or, as Joh. Müller calls them, "sense-substances" (*Sinnsubstantzen*), a motion that is in all cases ultimately identical. As in the experiment suggested by Bidder and successfully made by Vulpian on the nerves of taste, and those of the muscles of the tongue, the sensory and motor nerves, on being cut across, so heal together that excitation of the one class of fibres is transmitted by the cicatrix to the other class: in like manner, were the experiment possible, fibres from different sets of nerves would blend perfectly together. With the nerves of vision and of hearing severed, and then crossed with each other, we should with the eye hear the lightning-flash as a thunder-clap, and with the ear we should see the thunder as a series of luminous impressions. Sense-perception, therefore, as such, has its rise in the "sense-substances." It is these substances that translate the identical excitation of all the nerves into sense-perceptions, each set, according to its own nature, acting as carriers of Joh. Müller's "specific energies," and so giving quality. The Mosaic dictum, "There was light," is physiologically false. Light first was when the first red eye-point of an infusorial animal for the first time distinguished light from darkness. In the absence of the sense-substance of sight and hearing, this bright, glowing, resonant world around us would be dark and voiceless.

And voiceless and dark in itself, i. e., property-less, as the universe is on subjective decomposition of the phenomena of sense, so is it also from the mechanical stand-point, gained by objective contemplation. Here, in place of sound and light, we have only the vibrations of a primitive, undifferentiated matter, which here has become ponderable, and there imponderable.

But, however well grounded these views may be in general, nothing, as we may say, has been done toward carrying them out in detail. The philosopher's stone that should transmute into one another the as yet unanalyzed elements, and produce them from a higher element, if not from primeval matter itself, must be discovered before the first conjecture as to the development of apparently heterogeneous, from actually homogeneous matter, becomes possible.

Though the human mind will ever remain very remote from the mind imagined by Laplace, yet this is only a matter of degree, in some measure like the difference between a given ordinate of a curve and another immeasurably greater, though still finite, ordinate of the same curve. We resemble this mind, inasmuch as we conceive of it. We might even ask whether a mind like that of Newton does not differ less from the mind imagined by Laplace, than the mind of an Australian or of a Fuegian savage differs from the mind of Newton. In other words, the impossibility of stating and integrating the differential equations of the universal formula, and of discussing the result, is not fundamental, but rests on the impossibility of getting at the necessary determining facts, and, even where this is possible, of mastering their boundless extension, multiplicity, and complexity.

Thus the knowledge of Nature possessed by the mind imagined by Laplace, represents the highest thinkable grade of our own natural science. Hence we may lay this down as the basis of our inquiry as to the limits of this science. Whatever would remain unknown to such a mind, must be perfectly hidden away from our minds, which are confined within much narrower bounds.

There are two positions where even the mind imagined by Laplace would strive in vain to press on farther, and where we have to stand stock-still.

In the first place we must observe that the knowledge of Nature already spoken of as provisionally satisfying our desire of tracing things to their causes, in reality does no such thing, and is not knowledge at all. The conception of the world as consisting of minute parts that have always existed, and that are indestructible, and whose central forces produce all motion, is only a sort of substitute for an explanation. As has been remarked, it reduces all changes in the physical world to a constant sum of forces and a constant quantity of matter, and thus leaves in the changes themselves nothing that requires explanation. Given the existence of this constant, we can, in our joy for this new insight, be content for a little while; but soon we long to penetrate deeper, and to comprehend it in its own substance. The result is, as all know, that within certain limits the atomic theory is serviceable, and even indispensable for our physico-mathematical studies, but that when we overtax it, and make demands upon it that it is not intended to meet, then as a corpuscular philosophy it leads to interminable contradictions.

A physical atom, i. e., a mass which, as compared with bodies with which we are acquainted, is held to be infinitesimal, but yet, regardless of its name, ideally divisible, and to which properties or a state of motion is attributed, whereby the behavior of a mass consisting of countless such atoms is explained—such a notion is a fiction quite congruous in itself, and under certain conditions a useful fiction in mathematical physics. But, latterly, atoms have been as far as possible discarded in favor of volume-elements of bodies regarded as continuous.

A philosophical atom, on the other hand, i. e., a presumably indivisible mass of inert and inefficient substratum, from which proceed through vacant space efficient forces, is, on closer consideration, a chimera.

For, if this indivisible, inert, by itself ineffective, substratum is to have any actual existence, it must occupy a certain space, however small; and, in that case, we cannot see how it can be indivisible. Then, too, it can occupy space only on condition that it possesses perfect hardness, i. e., that it resists the intrusion into the same space of any other body, in virtue of a force exerted out to its own limits, though not overstepping them, which excludes all other bodies, and which must therefore be greater than any other given force. Not to mention any of the other difficulties which meet us here, we may observe that the substratum is thus represented as no longer inefficient.

But if with the dynamists we conceive of the substratum as being only the middle point of the central forces, then the substratum does not occupy space, for a point is the very negation of space *in* space. Hence we have nothing from which the central forces spring; nothing that could be inert, like matter.

The idea of forces operating at a distance through vacant space is unthinkable, nay, even self-contradictory; though, since Newton's day, owing to a misunderstanding of his doctrine, and in the face of his express warning, it has been a current conception among investigators of Nature. If with Descartes and Leibnitz we consider all space as occupied, and all motion produced by transfer to bodies in contact, the origin of motion is indeed reduced to a concept derived from our sense-experiences, but this view has also its difficulties. To mention only one of these, it is impossible in this hypothesis to explain the different densities of bodies from different combinations of a homogeneous original matter.

The origin of these contradictions is readily detected. They have their root in our incapacity to conceive of any thing save what we have experienced by either our external or our internal sense. In our endeavor to analyze the physical world, we start out from the divisibility of matter, the parts being to our eyes something simpler and more primitive than the whole. When in thought we carry on this division of matter *ad infinitum*, we act in perfect accordance with our sense-perceptions, and we meet with no obstacle in the process. But we make no advance whatever toward an understanding of things, since we, in fact, carry over into the region of the minute and the invisible the concepts we obtained in the region of the gross and the visible. Thus it is that we acquire the notion of the physical atom. If now we arbitrarily stop the process of dividing at some point where we are supposed to have reached philosophical atoms, that are indivisible, perfectly hard, and furthermore *per se* inefficient, being merely the carriers of the central forces, we are expecting that a matter which we think of under the concept of matter as known to us should, without the aid of any new principle of explication, develop new primordial properties, to explain the nature of bodies. Thus we commit the error which is manifested in the previously-mentioned contradictions.

No one, that has bestowed any thought on this subject, can fail to acknowledge the transcendental nature of the obstacles that face us here. However we try to evade them, we ever meet them in one form or another. From whatever side we approach them, or under whatsoever cover, they are ever found invincible. The ancient Ionian physical philosophers were no more helpless than we in presence of this difficulty. The natural sciences, with all the progress they have made, have availed naught against it, nor will their future progress be of any greater effect. We shall never know any better than we now do (to use the words of Paul Erman), "*was hier im Raume spukt*," the spectre that haunts the world of matter. For even the mind imagined by Laplace, exalted as it would be high above our own, would in this matter be possessed of no keener insight than ourselves, and hence we despairingly recognize here one of the limitations of our understanding.

But if we turn aside from this primordial limit, and postulate matter and force as understood, then, as we have said, the physical world is intelligible ideally. From the original condition of a revolving nebular sphere, the Kantian hypothesis, as further developed by Helmholtz with the aid of the mechanical theory of heat, leads to a conception of the origin of our planetary system. We first see our earth revolving in its orbit as a glowing fluid drop with an atmosphere of undefinable constitution. In the course of immeasurable intervals of time we see it become coated over with a crust of indurating primordial rock; sea and land are divided, eruptions of hot carbonic acid break up the granite, and give material for strata of alkaline earths, and finally the conditions arise under which life became possible.

Where and under what form life first appeared, whether at the bottom of the deep sea, as bathybius protoplasm, or whether with the co-operation of the still excessive ultra-violet solar rays, with still higher pressure of carbonic acid in the atmosphere, who can tell? But Laplace's Mind *could* tell, with the aid of the universal formula. For, when inorganic matter coalesces to form organic matter, there is only a question of motion, of the arrangement of molecules into states of more or less stable equilibrium, and of an exchange of matter produced partly by the tension of the molecules, and partly by motion from without. What distinguishes living from dead matter, the plant and the animal, as considered only in its bodily functions, from the crystal, is just this: in the crystal the matter is in stable equilibrium, while a stream of matter pours through the organic being, and its matter is in a state of more or less perfect dynamic equlibrium, the balance being now positive, again approaching zero, and again negative. Hence, without the interference of extraneous masses and forces, the crystal will remain forever what it is, whereas the organic being depends for its existence on certain exterior conditions, transforms potential into kinetic energy, and *vice versa*, and has a definite duration in time. Thus we see, that though there is no fundamental difference between the forces operating in the crystal and in the organized being, still the two are incommensurable, just as a simple building is incommensurable with a factory into which coal, water, and raw material pass, on this side, while at the other side carbonic acid, water, vapor, smoke, ashes, and the products of the machinery, are sent out. The building we may regard as so made up of parts, each resembling the total result, that, like the crystal, it is separable into like parts; the factory, like the organic being (if we abstract from the cellular constitution of the latter, and the divisibility of sundry organisms), is an Individual.

It is therefore an error to recognize, in the first appearance of living things on the earth, any thing supernatural, or any thing else save an exceedingly difficult mechanical problem. This is one of the two errors to wich I proposed to call attention. The other limit of natural science is not here, any more than in the fact of crystallization. Were we able to create the conditions under which organic beings had their rise, which we are not even able to do for all crystals, then, according to the principle of actualism, we could produce organic beings now in the same way that they were first produced. And even though we never could succeed in observing the original production of organisms—to say nothing of experimenting on it—that fact would constitute no absolute objection to our view. Were matter and force intelligible to us, the world would not cease to be so, even though we should conceive the earth to be covered with the most luxuriant growth of vegetable life, from its emerald equatorial girdle to the last lichen-gray cliffs of the pole; and it would remain equally so, whatever share in the formation of the vegetable world we might concede to the laws of organic development, or to natural selection.

But, for reasons which will readily appear, we must leave out of view, in the present consideration, the now well-known indispensable aid rendered by insects in the fertilization of plants. For the rest, the grandest picture ever sketched of a primeval forest in the tropics by Bernardin de St. Pierre, Von Humboldt, or Pöppig, offers to the view of theoretical science absolutely nothing but matter in motion. This, I think, is the new and very simple form that can be given to the argument against "life-force," in the sense of the vitalists.

But now there comes in, at some point in the development of life upon the earth which we cannot ascertain—the ascertainment of which does not concern us here—something new and extraordinary; something incomprehensible, again, as was the case with the essence of matter and force. The thread of intelligence, which stretches back into negatively-infinite time, is broken, and our natural science comes to a chasm across which is no bridge, over which no pinion can carry us: we are here at the other limit of our understanding.

This other incomprehensible is consciousness. I will now, conclusively as I believe, prove that not only is consciousness unexplainable by its material conditions in the present status of science, which every one will readily admit, but that, even in the nature of things, it never can be explained by these conditions. The contrary opinion, that we must not give up all hope of getting at consciousness from its material conditions, and that in the course of hundreds or thousands of years the mind of man, having invaded now unthought-of realms of knowledge, might succeed where we fail—this is the other error which I propose to combat here.

I use the term "consciousness" designedly, the question here being only as to the fact of an intellectual phenomenon, of any kind whatsoever, even of the lowest grade. There is no need to think of Watt, engrossed with his parallelogram, nor of Shakespeare, Raffaelle, or Mozart, engaged in producing their grand creations, in order to have an instance of a mental fact unexplainable by its material conditions. Just as the most powerful and best developed muscular performance of man or animal is in fact no more obscure than the simple contraction of a single muscle—as the single secretory cell involves the whole problem of secretion—so the most exalted mental activity is no more incomprehensible in its material conditions than is the first grade of consciousness, i. e., sensation. With the first awakening of pleasure or pain, experienced on earth by some creature of the simplest structure, appeared that impassable gulf, and then the world became doubly incomprehensible.

Few subjects have been more perseveringly studied, more written about, or more hotly disputed, than that of the connection between body and soul in man. All the philosophical schools, as also the fathers of the Church, have had their own opinions upon this matter. The more recent philosophy is less concerned with this question; but its beginnings in the seventeenth century abounded in theories of the interaction of matter and mind.

Two hypotheses set up by Descartes shut off that philosopher from all possibility of understanding this interaction. First, he held that body and soul are two different substances, united by God's omnipotence, and that, since the soul has no extension, they can come into contact only at one point, to wit, in the so-called pineal gland of the brain. He held, secondly, that the quantity of motion in the universe is constant. The more clearly it seems to follow from this that the soul cannot produce motion in matter, the more amazed are we on seeing Descartes, in order to save free-will, represent the soul as simply producing motion in the pineal gland, in such a way that the animal spirits, or, as we would say, the nervous principle, may flow out to the appropriate muscles. Conversely, the animal spirits, excited by sense-impressions, give motion to the pineal gland, and then the soul, which is in association with the latter, notes the motion.

Descartes's immediate followers, Clauberg, Malebranche, Geulincx, endeavored to correct this patent error. They insist upon the impossibility of interaction between mind and matter, as being two distinct substances. But, in order to understand how the soul nevertheless moves the body, and is moved by it, they suppose that the soul's willing is the occasion for God each time moving the body in harmony with the soul's desire. Conversely, sense-impressions give occasion to God to modify the soul in conformity with themselves. The *causa efficiens*, therefore, of the changes in the body wrought by the soul, and *vice versa*, is always God, and the soul's willing and the sense-impressions are but the *causæ occasionales* of the perpetually-renewed interventions of Omnipotence.

Finally, Leibnitz explained this problem on the hypothesis, originated, as it would appear, by Geulincx, of body and soul resembling two watches, with synchronous movement. This, says he, may occur in three ways: 1. The two watches might so influence one another by means of oscillations, conveyed to a common attachment, that their movements should be synchronous, as was observed by Huyghens, and as was exemplified, in the beginning of the present century, by Breguet, in a contrivance for rendering the action of two watches more uniform. 2. One of the watches might be constantly regulated, so as to keep it uniform with the other. 3. The watchmaker might be so skillful as to be able to make both go together, though independent of one another. As between body and soul, the first contrivance is clearly impossible. The second, which agrees with the occasionalist doctrine, is unworthy of God, whom it employs as a *Deus ex machina.* The third then remains, and here we find again Leibnitz's peculiar doctrine of Preëstablished Harmony.

But these and all similar views are discredited by the more recent investigations of natural science, and are void of all influence in modern thought, by reason of the dualistic principle on which they rest, in conformity to their semi-theological origin. The propounders of these theories start out from the hypothesis of a spiritual substance absolutely diverse from the body, viz., the soul, and their study is to investigate its association with the body. They find that the coupling of these two substances is possible only by a miracle, and that even after this first miracle another association of the two cannot take place except by means of a fresh miracle, or of a continuous miracle, dating from creation. This consequence they give out as a new solution of the problem, though they never took sufficient pains to inquire whether they themselves have not attributed to the soul such a nature that mutual interaction between it and the body is unthinkable. In short, the most satisfactory demonstration of the impossibility of the interaction of soul and body leaves room to question whether the premises were not arbitrary, and whether consciousness may not be regarded as simply the effect of matter, and so perhaps understood. Hence, the student of natural science demands that the argument to show that mental phenomena are unintelligible from their material conditions shall have nothing to do with any hypothesis as to the origin of such phenomena.

Astronomical knowledge of a material system I call such a knowledge of all its parts, their respective positions and their motions, that their position and motion, at any given time, past or future, may be calculated with the same certainty as we calculate the position and motion of the heavenly bodies, by means of previous absolute accuracy of observation and perfection of theory. To get the differential equation whose integration will give the desired results, we need only have, as it were, three positions of the parts of the system; i. e., we must know the position of the parts of the system at three successive instants, separated by two differentials of time. From the difference of the courses run in the equal and infinitesimal periods of time between the three we deduce the forces acting upon the system and within it.

In our incapacity to comprehend matter and force, astronomical knowledge of a material system is the completest knowledge we can expect to acquire of it. With this our instinct of causality is wont to be satisfied, and this is the kind of knowledge that would be possessed even by the Mind imagined by Laplace, if it made due use of its universal formula.

Now, suppose we had such astronomical knowledge as this, with regard to a muscle, a gland, an electrical organ, or a luminiferous organ in the state of excitation; of a ciliary cell, a plant, an ovum in contact with the sperm, or of a fruit at some stage of its development. In that case we should possess the fullest possible knowledge of these material systems, and our instinct of causality would be so far satisfied that we should desire nothing more, save to know what matter and force themselves are. Muscular contraction, secretion by the gland, the shock of the electrical, and the shining of the luminiferous organ; ciliary action, growth and chemical action of the cell in the plant; impregnation and development of the egg—all these phenomena, now hopelessly obscure, would be as evident for us as the movements of the planets. On the contrary, if we make a like supposition of astronomical knowledge, with regard to the brain of man, or even the soul-organ of the lowest animal, whose mental activity may be restricted to the sensation of pleasure and pain, then, so far as all the material phenomena are concerned, our knowledge would be as perfect, and our instinct of causality as satisfied, as in the case of muscular contraction or secretion, provided we had astronomical knowledge of muscles or glands. The involuntary actions of the centres, and those not necessarily connected with sensation—reflex action, simultaneous action, respiratory movements, growth and decay of the brain and spinal cord—would be completely understood. Further, those phenomena which are always, and hence necessarily, simultaneous with mental phenomena, would also be perfectly understood. And it certainly were a great triumph of human knowledge if we were able to say that, on occasion of a given mental phenomenon, a certain definite motion of definite atoms would occur in certain definite ganglia and nerves. It would be profoundly interesting if we could thus, with the mind's eye, note the play of the brain-mechanism, in working out a problem in arithmetic, after the manner of a calculating-machine; or, even if we could say what play of the carbon, hydrogen, nitrogen, oxygen, phosphorus, and other atoms, corresponds to the pleasure we experience on hearing musical sounds; what whirl of such atoms answers to the climax of sensual enjoyment; and what molecular storm to the raging pain we feel when the trigeminus nerve is misused. The intellectual enjoyment afforded by Fechner's preliminary studies in psychophysics, and by Donders's measurements of the duration of simpler mental operations, gives reason to expect that such direct insight into the material conditions of mental phenomena would be highly instructive.

Still, as regards mental operations themselves, it is clear that, even with astronomical knowledge of the mind-organ, they would be as unintelligible as they are now. Were we possessed of such knowledge, they would still remain perfectly unintelligible. Astronomical knowledge of the brain—the highest grade of knowledge we can expect ever to have—discloses to us nothing but matter in motion. But we cannot, by means of any imaginable movement of material particles, bridge over the chasm between the conscious and the unconscious.

Motion can only produce motion, or be converted back into potential energy. Potential energy can only produce motion, maintain static equilibrium, or exert pressure or traction. The sum of energy, however, remains the same. Beyond this law nothing can go in the physical world, nor can any thing fall short of it; the mechanical cause passes completely into the mechanical effect. Hence the mental phenomena, which in the brain appear in company with material phenomena, are, so far as our understanding is concerned, void of sufficient basis. They lie beyond the law of causality, and hence are unintelligible, like a *mobile perpetuum*. But they are also unintelligible on other grounds.

True, on superficial observation, it looks as though certain mental operations and conditions might be intelligible to us, from a knowledge of the material phenomena of the brain. Among such mental phenomena I might reckon memory, association of ideas, habit, specific talents, etc. It needs but little reflection to show that this is an error. We should only be acquainted with certain inner conditions of the soul's life, which are of about equal import with the external conditions created by sense-impressions; but we should know nothing about the origin of mental life in virtue of these conditions.

What conceivable connection subsists between definite movements of definite atoms in my brain, on the one hand, and on the other hand such (for me) primordial, indefinable, undeniable facts as these: "I feel pain, or pleasure; I experience a sweet taste, or smell a rose, or hear an organ, or see something red," and the immediately-consequent certainty, "Therefore I exist?" It is absolutely and forever inconceivable that a number of carbon, hydrogen, nitrogen, oxygen, etc., atoms should not be indifferent as to their own position and motion, past, present, or future. It is utterly inconceivable how consciousness should result from their joint action. If their respective positions and their motion were not indifferent to them, they would have to be regarded as each possessed of a consciousness of its own, and as so many monads. But this would not explain consciousness in general, nor would it in the least assist us in understanding the unitary consciousness of the individual.

That it is and ever will remain utterly impossible to understand higher mental operations from the mechanics of the cerebral atoms (supposing them to be known), needs not to be proved. Yet, as has been already remarked, we need not consider the higher forms of mental activity, in order to add weight to our argument. But its force is intensified by contrasting the absolute ignorance wherein astronomical knowledge of the brain leaves us with regard to the origin of the lowest mental phenomena, and the complete solution of the highest problems of the physical world which we get from such knowledge. A brain that should, from one cause or another, be unconscious—for instance, one that should sleep without dreaming—would, had we astronomical knowledge of it, hold no secret; and, if we possessed astronomical knowledge of the rest of the body also, then the whole human machine, with its respiration, its heart-beats, its exchanges of materials, its heat, etc.—in short, every thing short of the essence of matter and force, would be fully deciphered. The dreamless sleeper is comprehensible to us, like the universe previous to consciousness. But, as, on the first awakening of consciousness, the world became doubly incomprehensible, so too is it with the sleeper, at the first appearance of a faint image in dreaming.

The irreconcilable conflict of the mechanical view of the universe with freedom of will, and hence indirectly with ethics, is no doubt a matter of high importance. The ingenuity of thinkers in all times has been exhausted in trying to reconcile them, and this question will afford exercise to the mind of man forever. To say nothing of the fact that free-will may be denied, whereas pleasure and pain are unquestionable; *desire*, which gives the impetus to exertion, and hence gives occasion to act, or not to act, is necessarily preceded by sense-impressions. Hence it is to the problem of sensation, and not, as I have once said, to that of free-will, that analytical mechanics leads.

And here is the other limit of our knowledge of Nature. It is no less absolute than the first limit. For two thousand years, despite all the advances made by natural science, mankind has made no substantial progress toward the understanding of matter and force, any more than toward the understanding of mental activity from its material conditions. And so will it ever be. Even the Mind imagined by Laplace, with its universal formula, would, in its efforts to overstep these limits, be like an aëronaut essaying to reach the moon. In its world of mobile atoms, the cerebral atoms are in motion indeed, but it is a dumb show. This Mind views their hosts, and sees them crossing each other's course, but does not understand their pantomime; they think not for him, and hence, as we have already seen, the world of this Mind is still meaningless.

In this Mind we have the measure of our own capacity, or rather our impotence. Our knowledge of Nature is thus shut up between two limits, the one forevermore determining our incapacity to comprehend matter and force, the other determining our inability to understand mental facts from their material conditions. Between these limits the man of science is lord and master; he dismembers and builds up, and no one durst say wherein his knowledge and his power are circumscribed. Beyond these limits he cannot now, nor can he ever, go.

But the more frankly the student of natural science acknowledges these appointed limits, and the more humbly he is reconciled to this ignorance, the more profoundly conscious is he of his right inductively to fashion his own views as to the relations between mind and matter, with perfect freedom, and untrammeled by myths, dogmas, or time-honored philosophies.

He sees material conditions in a thousand ways influencing mental life. To his unprejudiced mind there seems no reason to doubt that sense-impressions are really communicated to the so-called Soul. He sees the human mind grow with the brain as it were, and, according to the empiricists, he finds that the actual forms of his thought are constituted by means of external perceptions. In sleep, and in dreams, in fainting, in intoxication and narcosis, in the delirium of fever and in inanition, in mania, epilepsy, idiocy, microcephaly—in a thousand morbid states he sees the soul to be dependent on the constant or transient condition of the brain. No theological prejudice prevents him, as it did Descartes, from recognizing in the souls of animals the relatives of the human soul, and less perfect members of the same series of development. On the contrary, he sees that in the vertebrates those parts of the brain which physiological research and pathological experience prove to be the seat of the higher mental activities keep pace, in their comparative development, with the growth of these activities. Where mental capacity makes the immense leap from the anthropoid apes to man which is indicated by the power of speech, we find a corresponding leap in cerebral mass. The varied arrangement of similar elementary particles in the invertebrates instructs the investigator of Nature that here, as in other organs, there is question less of the general architecture than of the structural elements.

With awe and wonder he regards the microscopic molecule of nervous substance which is the seat of the laborious, constructive, orderly, loyal, dauntless soul of the ant. Finally, the development theory, coupled with the doctrine of natural selection, forces upon him the theory that the soul came into being as the result, gradually attained, of certain material combinations, and that probably, like other heritable endowments that are of use to the individual in the struggle for life, it has risen and perfected itself up to its present state through a countless series of generations.

Now, if the ancient thinkers found every interaction between body and soul unintelligible and impossible on their theories, and if their undoubted simultaneous coöperation is to be explained only by a Pre-established Harmony of the two substances, then the notion they formed of the soul, in conformity with their scholastic conceptions, must have been erroneous. The necessity of a scholastic conclusion so plainly in conflict with the reality, is, as it were, an apogogical demonstration of the falsity of their premises. In his simile of the two watches, Leibnitz, as has been well observed by Fechner, overlooked the fourth and simplest supposition, viz., that perhaps the watches, whose simultaneous action is to be accounted for, may be after all only one. Whether we shall ever understand mental phenomena from their material conditions is a very different question from that other, viz., whether these phenomena are the product of material conditions. The former question might be decided in the negative without in the least affecting the latter, to say nothing of negativing it.

In the passage we have already cited, Leibnitz asserts that a mind incomparably higher than the human mind, but yet finite, could, if it were possessed of senses and technical powers of like perfection, form a body capable of mimicking the actions of man. He does not say that a man could be formed, for in his view the automaton of flesh and bone, which he regards as soulless, even as Descartes regarded all animals, still lacks the mechanically-incomprehensible soul-monad. The difference between Leibnitz's point of view and our own becomes very evident here. Imagine all the atoms whereof Cæsar was made up at a given moment, say as he stood at the Rubicon, to be by mechanical power brought together, each in its own place, and possessed of its own velocity in its proper direction. In our view Cæsar would then be restored mentally as well as bodily. This artificial Cæsar would at the first instant have the same sensations, ambitions, imaginings, as his prototype on the Rubicon, and the same memories, the same inherited and acquired faculties, etc. Suppose several artificial figures of the same model to be simultaneously formed out of a like number of other carbon, hydrogen, etc., atoms. What would at the first moment be the difference between the new Cæsar and his duplicate, beyond the differences in the places where they were formed? But the mind imagined by Leibnitz, after fashioning the new Cæsar and his many Sosiæ, could never understand how the atoms he himself had disposed in order, and set into action with proper velocity, could give mental activity.

Take Carl Vogt's bold expression, which in 1850 introduced a sort of mental tournament: "All those capacities which we call mental activities are only functions of the brain; or, to use a rather homely expression, thought is to the brain what the bile is to the liver, or the urine to the kidneys." The unscientific world were shocked at the simile, considering it to be an indignity to compare thought with the secretion of the kidneys. Physiology knows no such æsthetic discriminations of rank. In the view of physiology the kidney secretion is a scientific object of just the same dignity as the investigation of the eye, or the heart, or any so-called "nobler" organ. Nor is Vogt's expression worthy of blame on the ground that it represents mental activity as being the result of material conditions in the brain. Its faultiness lies in this, that it leaves the impression on the mind that the soul's activity is in its own nature as intelligible from the structure of the brain, as is the secretion from the structure of a gland.

Wherever the material conditions of mental activity in the shape of a nervous system are lacking, as is the case with plants, the scientist cannot admit the existence of soul-life; and here he but seldom finds his views controverted. But what answer is to be made him if he were to require, as the condition of his believing in a soul of the universe, that there should be shown to him somewhere in the world, bedded in neuroglia, and nourished with warm arterial blood under due pressure, a system of ganglia and nerves corresponding in extent to the mental power of such a soul?

Finally, the question arises whether the two limits of our knowledge of Nature are not perhaps identical, i. e., whether, supposing we understood the nature of matter and force, we should not also understand how the substance that underlies them could, under certain conditions, feel, desire, and think. Certainly this is the simplest hypothesis, and, according to well-known principles of scientific research, until it is disproved it must be preferred to that other hypothesis, which, as we have said, makes the universe doubly incomprehensible. But such is the nature of things that we cannot attain clearness of view with regard to this point, and it were idle to dwell upon it.

With regard to the enigma of the physical world the investigator of Nature has long been wont to utter his "*Ignoramus*" with manly resignation. As he looks back on the victorious career over which he has passed, he is upheld by the quiet consciousness that wherein he now is ignorant, he may at least under certain conditions be enlightened, and that he yet will know. Bnt as regards the enigma what matter and force are, and how they are to be conceived, he must resign himself once for all to the far more difficult confession—

"IGNORABIMUS!"

THE CROOKED COURSES OF LIGHT.

AN article in the April MONTHLY explained the formation of luminous images upon the principle that light moves in straight lines through any uniform transparent medium; but at the same time no agency in Nature illustrates in so many ways its capability of being turned from a direct course. It may be thrown back by surfaces either directly in its own path, or at all possible angles, and it may be warped out of its course in various degrees as it passes through bodies, although in all cases the change of direction is governed by inflexible laws. The throwing back of rays from surfaces is known as the *reflection* of light; the bending or the fracture of the ray as it traverses a body is called the *refraction* of light.

The principle of reflection is illustrated in Fig. 1, in which a beam of the sun's rays enters through the shutter of a dark room, strikes upon a polished plane surface, and is reflected across the room in an opposite direction. The entering beam, *A B*, is called the incident ray. The vertical line, *B D*, is termed the *normal*, and the beam *B C*,

FIG. 1.

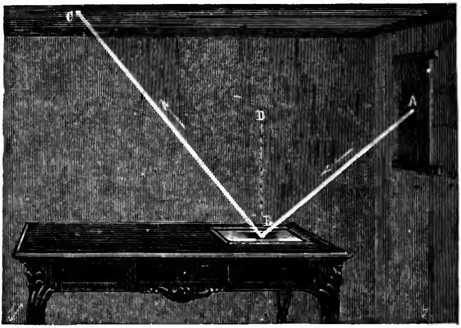


ILLUSTRATION OF THE REFLECTION OF LIGHT.

the reflected ray. The angle *A D B*, contained between the incident ray and the normal, is termed the angle of incidence; and the angle *C B D*, contained between the corresponding reflected ray and the normal, is called the angle of reflection. The reflection of light by polished surfaces, as in this case, is governed by two laws: 1. The incident ray, the normal, and the reflected ray, are always in the same plane; and, 2. The angle of incidence is always equal to the angle of reflection.

FIG. 2.

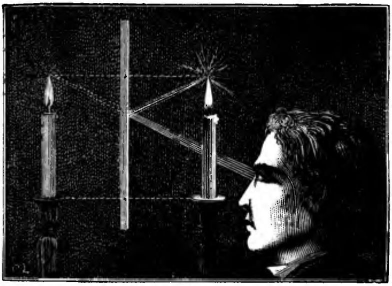
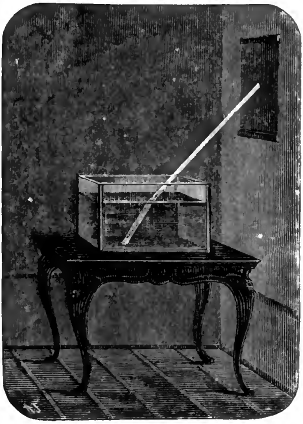


IMAGE OF A CANDLE IN A LOOKING-GLASS.

This is an example of what is known as *regular* reflection, but there is another kind of reflection in virtue of which bodies, when illuminated, throw back the light in all directions, and this is known as irregular reflection or diffusion. The effect of regular reflection, which depends upon the polish of surfaces, is not to make those surfaces visible, but to exhibit images of surrounding objects; it is by the light irregularly reflected upon their surfaces that objects are seen. In looking into a mirror, the image of the face is seen by regular reflection; the surface of the mirror is recognized by irregular reflection. "The mirrors of the ancients were of metal, usually of the compound now known as speculum-metal. Looking-glasses date from the twelfth century. They are plates of glass, coated at the back with an amalgam of quicksilver and tin, which forms the reflecting surface. This arrangement has the great advantage of excluding the air, and thus preventing oxidation. It is attended, however, with the disadvantage that the surface of the glass and the surface of the amalgam form two mirrors; and the superposition of the two sets of images produces a confusion which would be intolerable in delicate optical arrangements. The mirrors, or specula as they are called, of reflecting telescopes, are usually made of speculum-metal, which is a

Fig. 3.

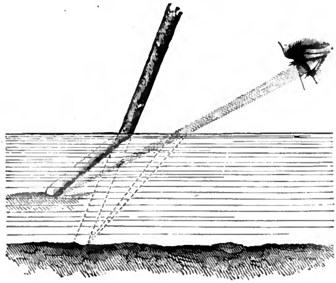


Refraction by Water.

bronze composed of about thirty-two parts of copper to fifteen of tin. Lead, antimony, and arsenic, are sometimes added. Of late years specula of glass coated in *front* with real silver have been extensively used; they are known as *silvered specula*. A coating of platinum has also been tried, but not with much success."

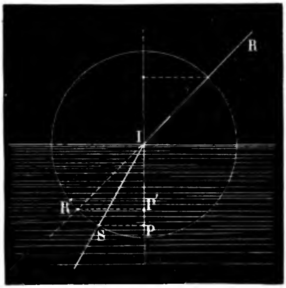
It is well known that the effect of plane mirrors or of any polished plane surface is to produce behind them images exactly similar both in form and size to the real objects in front of them. Fig. 2 represents the formation of an image of a candle in a common looking-glass. The reflection is shown as limited to the pencil of rays emitted by the highest point of the flame. The reflected rays which enter the eye are seen to be divergent like the incident rays, so that if they were produced backward they would meet at a point forming the image at the top of the flame. As all surfaces are made up of points, and each point of the object is reflected in the same manner, it is clear that the image formed by a plane mirror must symmetrically represent the object.

Fig. 4.



Appearance of a Stick in Water.

Fig. 5.



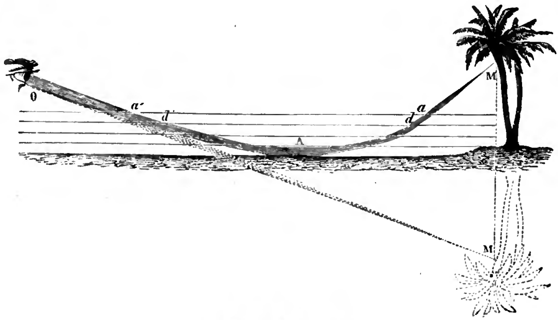
Snell's Law of Refraction.

But light-rays may be turned from their direct course in another way. When a beam passes obliquely from one transparent medium to another of different density, as from air to water or glass, its direction is changed and it is said to be refracted. This is illustrated in a very simple manner by Fig. 3, in which a ray of the sun, entering through an aperture in a dark room and received on the surface of water in a glass vessel, is seen to be broken as it were at the surface and bent downward.

A familiar experiment illustrating the same principle is to put a coin upon the bottom of an empty, opaque vessel, while the spectator places himself so that it is just hidden by the vessel's edge. If water be now poured into it, the bottom of the dish will appear to rise, and the coin will come in sight. The pencil of rays thus undergoes a sudden bend at the surface of the water, and reaches the eye by a crooked course, the effect of which is, that the spectator sees round or behind the obstacle. Fig. 4 shows how an inclined stick, partially immersed in water, presents a broken appearance. Transparent substances differ in this refracting power. Liquids exhibit it in a much higher degree than gases, and, as a general rule, the denser of two substances manifests the greater refracting effect. Hence it is common to speak of the change in the ray as it passes from a denser into a rarer medium, or the reverse.

Although a ray when passing from one medium to another is refracted at different angles depending upon its obliquity, yet the phenomenon is governed by one law and capable of being expressed in one formula. This is called the *index of refraction*, and was discovered by Willebrod Snell, a Dutch philosopher, about the year 1621. Fig. 5 will illustrate it. A circle is described around the point *I*, at which the ray *R* is incident upon the refracting surface. As the angle of the incident ray *R* varies with the normal, the angle of the refracted ray *S* will vary also. The law of refraction is, that the signs of these angles as *R′ P′*, *S P* will have a constant ratio. Each transparent substance has its index of refraction, and tables are given of these indices for different substances in the books upon physics.

FIG. 6.

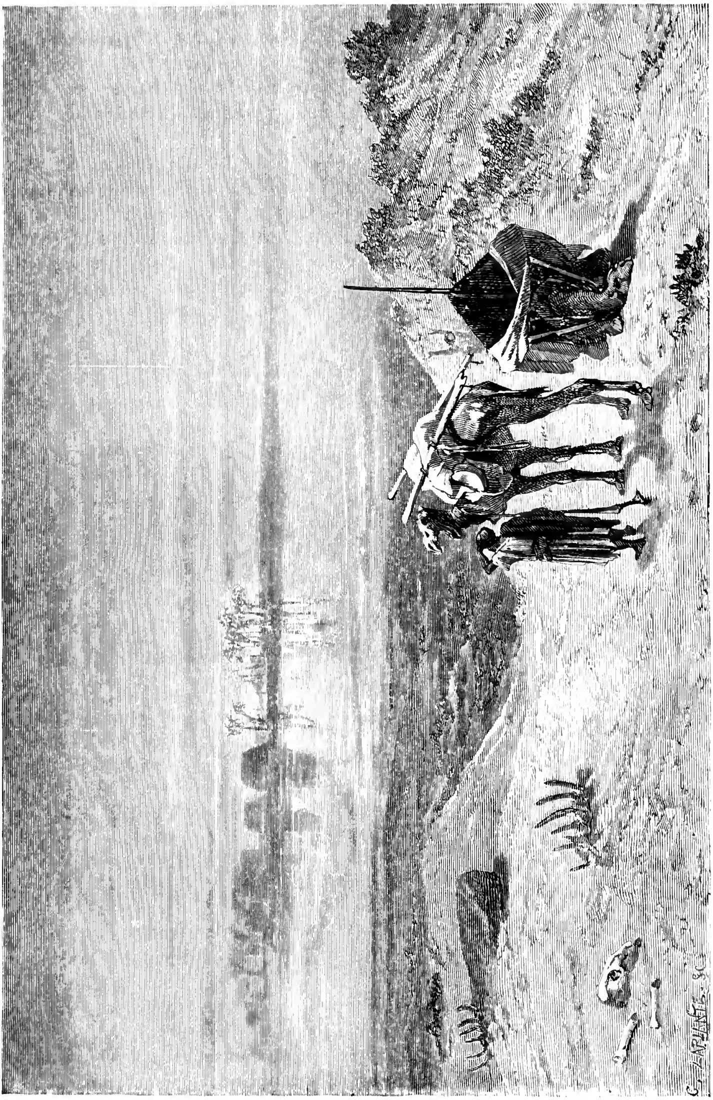


THEORY OF MIRAGE.

In order that a ray may be refracted, it is by no means necessary that it should pass through bodies of widely different qualities, as from gases to liquids, or from liquids to solids; the effect may be seen in passing from one liquid to another of a different density, as where liquid bisulphide of carbon is covered with a layer of water floating upon its surface. The ray will then be seen to be bent on entering the water, and still more bent on passing from the water into the layer of bisulphide of carbon. In the same way rays of light passing through layers of the atmosphere of different density, undergo successive refractions. As the atmosphere varies in its density as we ascend from the earth, the rays of the sun and stars in passing through them are bent in their course, so that in point of fact we see them all through crooked and varying paths.

An appearance, as of water, is often seen in sandy deserts, where the soil is highly heated by the sun. The observer sees in the distance the reflection of the sky and of terrestrial objects, as on the surface of a lake. Fig. 6 illustrates how this effect may be produced. The air near the ground becomes so highly heated and rarefied that its

Fig. 6.

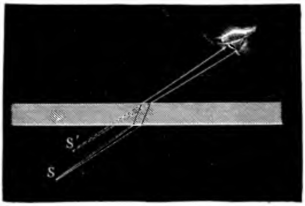


Mirage of the Desert.

density within a certain distance *increases upward.* A ray, *M A*, Fig. 6, proceeding obliquely downward, will be rendered by refraction more and more nearly horizontal, until it is at length totally reflected, and it is then by successive refractions gradually elevated till it meets the eye of the observer at *O*, who thus sees an inverted image at *M*. Fig. 7 shows this effect as seen in the desert, where the eye is cheated by the appearance of water.

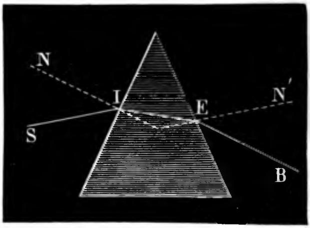
When a ray of light enters a piece of glass having parallel sides, as shown in Fig. 8, it is refracted, at the upper surface, downward, as in the case of water, and passes on straight until it reaches the lower surface. But, as it emerges, the reverse effect takes place, and the ray is refracted away from the perpendicular line. Its direction is now parallel to its original course, but it takes the path *S* instead of *S′*. The effect of this is, that whenever we look obliquely through plates of glass, as window-panes, all objects seen are slightly displaced, the degree of displacement varying of course with the thickness of the plate.

FIG. 8.



VISION THROUGH GLASS PLATE.

FIG. 9.



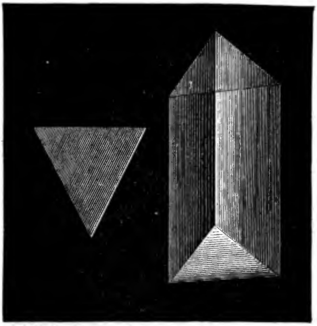
REFRACTION THROUGH PRISM.

If, now, we take a piece of glass, of a wedge-shape, in which the sides are not parallel, a different effect is produced by the passage of the light through it. Such a piece of glass, or any transparent substance bounded by surfaces in this way, is called a *prism.* In Fig. 9, the ray *S* is represented as striking the prism at *I*, and, as it enters the glass, it is refracted toward the thicker part, and emerges at *E*. As it passes out into the air it is again bent in the same direction toward the base of the prism. The dotted lines, *N I* and *E N′* are drawn perpendicular to the faces of the prism, or at right angles, and serve to show that the path of the ray through the prism also makes equal angles with its surfaces.

The lines at which the faces of a prism meet are called its edge. Those in use are generally triangular, and very frequently equilateral, as shown in Fig. 10. For experiment, when used separately, they are commonly mounted upon stands, as shown in Fig. 11, which has several joints. The uppermost is for rotating the prism about its own horizontal axis; the second is for tilting it at an angle with the horizon; the third is for turning it about a vertical axis; and the fourth for raising and lowering it through a range of several inches.

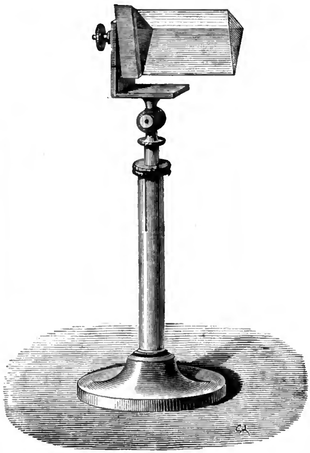
When a prism like that shown in Fig. 9 is interposed in the path of a narrow beam of sunlight, admitted into a dark room, its alteration

Fig. 10.



Equilateral Prism.

Fig. 11.



Prism mounted on Stand.

of the direction of the ray is easily seen, and it will be found that the course of the light is altered, by refraction, some 40° or 50° from its original course.

The properties of light, to which we have here briefly referred, are interesting in themselves, and important to be known; but they have additional interest as preparing for an understanding of spectrum analysis, which will be taken up and popularly explained in future numbers of the Monthly.

SYNTHETIC CHEMISTRY.

By Prof. JOHN W. LANGLEY,

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CHEMISTRY has been called *the* analytical science, and undoubtedly with justice in the past, since the most exact processes with which it deals are still those which go technically by the name of analysis; but, of recent years, the arts have been enriched by many perfumes, colors, and drugs, which are the results of careful and laborious construction on the part of the manufacturer, operating under chemical laws. Gradually there has arisen a new branch of the science, whose aim is to produce artificially new compounds out of old material; and, since the living vegetable and animal offer familiar though mysterious examples of the same process, it is only natural that the philosopher should have tried to obtain, by known methods, some of those results which are so silently and wonderfully wrought out by the substance of living tissue. It will be the object of this paper to indicate, in a non-technical way, some of the steps which have been taken in the effort to compete with vitality.

The word *synthesis*, in its broad or general acceptance, signifies the union of any two or more substances to form a physically-homogeneous mass, and into a product which cannot be mechanically divided into dissimilar parts. Under this definition nearly every operation of chemistry would be synthetical; for, even in the case where an element is isolated, this is done only at the expense of some other bodies which pass into the condition of compounds; thus, when gold is precipitated in a metallic state from solution, we must use iron, zinc, or some other substance, which shall become oxidized and dissolved in the place of the precipitated gold.

Most cases of synthesis take place with great facility, automatically in fact, for, when coal is burned, we start the fire, and after that the oxygen and carbon unite to form carbonic acid, without any further effort on our part.

Now, in the world there are vast numbers of distinct compounds, some of which have a simple and others a complex structure; it is found, by long experience, that there is a general disposition on the part of these substances to pass from the state of feebly-united units to that of great fixity; thus, wood, which is composed of carbon, oxygen, and hydrogen principally, burns in the air into two stable and incombustible bodies, carbonic acid and water; and, in so doing, evolves a large amount of heat. Neither of these final products, so formed, can in any way be caused to evolve a further amount of energy, without bringing in the aid of external matter; dynamically, they are dead, as physiologically an animal is, when no longer capable of movement.

To raise a body into a state so that it contains within itself force in a potential form, and so as to be able to liberate this force spontaneously, when certain conditions are fulfilled, is an operation opposed to the general tendencies of the material world, and directly contrary to what may be called the habits of non-vitalized matter. Now, it is precisely this thing, this act of elevating some limited portion of matter to a higher plane, where its potentiality and complexity are both increased, that is meant by chemical synthesis, and it will be seen how much this use of the term restricts the meaning of the words as ordinarily used.

To raise a weight from the ground, to make water run up-hill, or to generate heat by friction, are all processes which require the expenditure of effort and material substance, if we would perform them ourselves. So in Nature, *this* form of synthesis is never accomplished without the expenditure of energy from some source. In the vegetable, the power comes directly from the sun, and the world in summer is colder and less brilliant (by an infinitesimal amount, it is true), because of that growth of leaves and wood which in the winter we reconvert into heat and light in our stoves; the animal gets the force for its synthesis by eating and consuming the products of vegetable life; and the chemist in his laboratory obtains his power mainly by converting a large amount of some complex body into simpler ones, in order to raise a smaller portion of some other mass to a more loosely aggregated and heterogeneous condition.

Starting with the elements and simple mineral bodies, the construction of such substances as salts, by the union of an acid and a base; of a suffocating gas, by the combustion of sulphur; of the conversion of iron into rust, by the action of water, air, etc., is very easy up to a certain point—so easy, that probably the very earliest beginnings of chemistry lay in observations of these facts. Certainly, the historic origin of the science in alchemy leaves no doubt of it as regards the middle ages, and, at the present day, most of the technical applications of the science are examples of the building up of compounds. So long as the experimenter's efforts were confined to mineral matter, he met with but little trouble; but, the moment he tried to reproduce any organic body, any compound which was the direct product of life, either animal or vegetable, he met a barrier which seemed to be insurmountable, and which bade fair never to be crossed. It was easy enough to analyze any of these vital products, and to determine the exact number and amount of their ingredients; but, once separated, the chemist vainly endeavored to make the elements reunite as they were before.

This was the state of things up to forty or fifty years ago. The power of the chemist had grown to be very great; he could either bind or loose, as pleased him, and he thought he had a tolerably complete knowledge of the elements and forces he was dealing with. Is it so much wonder, then, that he fell back on the assumption of the existence of a mysterious force outside of his domain, and that his defeat, coupled with the known impossibility of restoring life to the dead animal, should have led to the assumption that these organic bodies were the result of chemical processes which had been aided and controlled by a special entity, denominated vital force?

It is not the object of this paper to take sides on a question which is still a matter of debate; and, in regard to vital force, it has only to chronicle here some of the steps by which bodies, hitherto solely evolved by the action of living matter, may now, under the guidance of the human intellect, and by the instrumentality of physical forces, be formed artificially at will.

In 1828, Wöhler, a German chemist, discovered that cyanate of ammonia, a purely mineral compound, under certain circumstances became changed into urea, without either loss or gain of any foreign body, the elements rearranging themselves to form a more complex structure. But here it was claimed, by the vitalists, that urea, being an excrementitious substance, and one of the waste products of the animal system, must be considered as in reality a mineral, and only accidentally, as it were, akin to animal tissue.

There exists in the bodies of ants a secretion which apparently serves them as a weapon; it is called formic acid, and, for some years after its discovery, was universally prepared by pounding up sundry ounces of ants in a mortar, and distilling them with water, when the bodies of the insects were left in the retort, and a diluted acid was found in the receiver. Analysis showed this substance to be formed of but three elements, and which, moreover, did not appear to be united in a complex manner. From certain analogies it was inferred that the acid might be obtained by some method of gradual oxidation; at last, the right substance was found, and, by duly acting on starch by oxygen, formic acid was produced. This was considered a very great step in advance, for an animal product had been at last formed from a vegetable one; and though it is true the body in question had a simpler constitution than the starch, still the plane of possible chemical processes had been elevated into the animal kingdom.

Quite recently a method has been discovered by which formic acid may be generated directly from its elements. To do this, carbon, say a bit of charcoal or coke, is heated in a limited supply of air, and the result is carbonic oxide; this gas, if exposed for a long time over caustic potash, combines with it, and this product, if distilled with oil of vitriol, yields formic acid. Thus the body has been formed without any thing having been used which is the product of life.

From this point progress was rapid, though at first apparently it rather tended away from the matter at issue. Previous study in the department of mineral chemistry had gradually forced the conception that the *position* of the elements in a compound had as much to do with its properties as did their number and amount, and it also had developed the fact that certain elements might be withdrawn and their places filled by something else, without changing the general character of the substance. Indeed, a compound body was called a chemical structure, and likened to a real edifice, in which the elementary atoms were the bricks of the house, and the resulting properties constituted the shape of the building. Now, by replacing one element by another, the same kind of change was produced as would be caused by the substitution of marble for bricks, or iron for stone, in the real house. Its appearance and habitability might be greatly altered, but its general shape and character remained.

As an example of this class of syntheses, the alcohols may be cited. Ordinary or wine alcohol is one of a large class of bodies which have similar features, and to which the same general name has been given; they constitute a series: thus, we have methylic alcohol, vinic alcohol, tetrylic alcohol, and so on. Now, in most of these we can substitute certain metals for hydrogen; for instance, metallic zinc can be thus inserted, and hydrogen removed, yielding zinc-ethyl, and, with the addition of oxygen, zinc-alcohol, and we get a colorless, fragrant liquid, in which, singularly enough, the zinc has so far lost its usual characteristics as to be both invisible and volatile. By carrying on the steps of this process still further, several metals may be introduced leading to the production of bodies of great resultant complexity, but which, through all their metamorphoses, are yet true members of the alcohol family.

In this sense the artificial processes may be said to surpass the natural ones; for man is able to add many individuals to a series of which Nature presents us with only scattered terms; and, in addition, in this particular group, he is able to form some of the natural members, such as wine alcohol and glycerine, by a direct process of construction, starting with the free elements, carbon, hydrogen, and oxygen. The method is briefly as follows: Carbon, in the form of black-lead, and therefore strictly a mineral substance, is heated intensely between the poles of a galvanic battery; when it is brilliantly incandescent, hydrogen gas is made to pass over its surface, in a suitable apparatus, the sides of which are kept comparatively cool, and the result is the formation of an invisible but extremely irritating gas, known as acetylene. Now, if acetylene is brought into a solution of copper, it combines with it, forming a dark-red explosive compound, and, if we act upon this body by hydrogen, the copper will be expelled, and olefiant gas, a sweetish ethereal substance, is obtained; and, finally, by distilling this last with sulphuric acid, alcohol is one of the products. Thus, in the several steps leading to this result, only mineral matter and ordinary chemical forces have been employed.

It must not be inferred, from the above meagre examples, that the number of syntheses is equally limited. Already there have been formed several natural vegetable acids, many of the alcohol family, some of the sugars, a whole host of ureas, a multitude of bodies analogous to the vegetable alkaloids, as well as many of the natural flavoring and coloring agents; these last, indeed, on an extended commercial scale.

So far as the evidence of experience goes, there seems no limit to the possible production of organic bodies which possess a definite chemical structure, at least of those which have the power of crystallizing, for the number, even now beyond the powers of an ordinary memory, is constantly increasing in an accelerating ratio, and already, as has been referred to, in some instances exceeds the range of Nature herself.

But are we entitled from these facts to indulge in self-glorification, and to assert that ultimately the exact reproduction of all the tissues found in living organisms will be possible? Certainly not, so far as the chemist is concerned, for other methods than those which properly belong to his science must obviously be sought to give the specialized forms and functions of living substance. The gulf which separates the artificial processes of synthetic chemistry from those really employed by the plant or animal is a wide one, across which lies as yet no solid bridge of fact and theory. It is known that all vegetable matter is derived primarily from carbonic acid, water, and ammonia, under the influence of the sun's rays, but the method by which this is done is still a mystery; a mystery, though, which may be cleared away, for very recently most interesting experiments have been made on the chemical action of light. All we know about vegetable chemistry with certainty is, that, whatever are the processes occurring in living tissue, most of them, in their earlier stages, are radically different from those of art. In the laboratory, synthesis starts with the elements, and from them, by exceedingly wasteful means, builds laboriously, from platform to platform, up to the desired height. On the other hand, the smallest speck of green vegetable tissue, if living, elaborates its substance, not from elementary bodies, but from compound ones, and those too which are among the most stable and most highly-oxidized known; each new step, then, in the artificial method, tends to carry us away, rather than to approximate us to the natural agent.

To return to the metaphor of the house. The chemist starts from the ground, and completes the edifice by piling *up*, one by one, the elementary bricks, and binding them together by the natural cement of atomic attraction. The living organism begins its labors at the top, and chiefly from the three firmly-knit compounds, water, carbonic acid, and ammonia, builds, by infinite gradation, *down* to an elementary foundation; and, at this day, science is scarcely more able to tell how this is done, than can the mason inform us how to start a block of houses by commencing with the roof.

This distinction as to methods includes obviously a vast domain of facts, that which has been referred to as the region lying between the natural and artificial synthetic methods. It is a sort of debatable land, for, though it is yet unknown, there is not the slightest proof that we shall not cross it some day, and possibly soon; and already the space is inhabited by speculations and embryonic theories, those shadowy precursors of substantial knowledge.

But the limit where the chemist *must* stop is the dividing line where the naked individuality of a chemical compound becomes clothed by the definite outline of an organ, a cell, or a speck of vitalized protoplasm; as soon as form other than crystalline appears, the sharpness of atomic characteristics is merged in the idiosyncrasies of the cellular unit, and the chemist unaided can trace the work no further. A new set of forces apparently comes into play, and whether we say this new agent is vital force, or prefer to hold fast to scientific accumulations of facts and methods of thought, and regard the new mystery as but the result of new or changed conditions, it is equally evident that the province of pure chemistry ceases, for this limit was long ago self-assigned by the science, and indeed exists in a latent form in all its definitions.

Doubtless, either biology, or some as yet unspecified portion of science, drawn from the provinces of chemistry, physiology, anatomy, and physics, will take hold of this problem and solve it; to a certain extent is doing so now, and thus far the little light which has been gained seems to indicate the unbroken operation of uniform law acting through the known physical forces. Perhaps under this heading common gun-cotton offers one of the most striking examples. The cotton-fibre is an elongated cell, it is of course both vegetable and a special functional organ, and is therefore outside of what was above spoken of as the limit of pure synthesis; nevertheless, by the simple operation of immersing it in strong nitric acid, the properties of the tissue are remarkably changed. It has become highly combustible and explosive, and also soluble in a mixture of alcohol and ether. Now, the chemical change has consisted in a bodily removal of hydrogen, and the insertion into its place of a heavy red compound gas, and yet the shape, color, and texture of the cotton-fibre are so little altered that none but an expert can perceive any external change. Moreover, by a reverse process, gun-cotton can be changed back again into the ordinary article. It is, then, possible to most profoundly alter the chemical structure and properties of one of these organic cells without visibly changing its individual shape.

On the other hand, when gun-cotton is dissolved in ether, it becomes collodion, and when this solution is evaporated the vegetable tissue is left, not in its original fibrous form, but as an amorphous film; so here we have the cellular characteristics utterly destroyed by an agent which is not regarded as exerting any *chemical* action at all; and, by analogy, we may infer that the specialized forms of organized bodies are not therefore the necessary results of their atomic structure only.

Another example of the same kind is the facility by which certain crystals may be made to take on either an amorphous or an apparently cellular form. It is only necessary to add gum, or some other mucilaginous material, to the water in which they have been dissolved, to have them appear, on solidifying in this anomalous way, all their beautiful sharp angles and edges lost in a formless mass or in rounded nodules, like many of the renal and vesical calculi.

But this paper has already reached the limit of facts, and has perhaps entered too far into the region of speculation. In the controversy now going on, as to the spontaneous generation of life, some of the contestants have appealed triumphantly to the results of synthetic chemistry, as indicating clearly that the "arcana of life had been entered and the mysterious divinity, vital force, overthrown." Does it not rather appear that chemistry, as yet, had not cut the Gordian knot, but was rather compelled to look to other sets of forces than those known as chemical for the chief agencies concerned in this work?

UNIVERSITIES: ACTUAL AND IDEAL.[1]

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

ELECTED, by the suffrages of your four nations, rector of the ancient university of which you are scholars, I take the earliest opportunity which has presented itself, since my restoration to health, of delivering the address which, by long custom, is expected of the holder of my office.

My first duty, in opening that address, is to offer you my most hearty thanks for the signal honor you have conferred upon me—an honor of which, as a man unconnected with you by personal or by national ties, devoid of political distinction, and a plebeian who stands by his order, I could not have dreamed. And it was the more surprising to me, as the five-and-twenty years which have passed over my head since I reached intellectual manhood have been largely spent in no half-hearted advocacy of doctrines which have not yet found favor in the eyes of academic respectability—so that, when the proposal to nominate me for your rector came, I was almost as much astonished as was Hal o' the Wynd, "who fought for his own hand," by the Black Douglas's proffer of knighthood. And I fear that my acceptance must be taken as evidence that, less wise than the Armorer of Perth, I have not yet done with soldiering.

In fact, if, for a moment, I imagined that your intention was simply, in the kindness of your hearts, to do me honor, and that the rector of your university, like that of some other universities, was one of those happy beings who sit in glory for three years, with nothing to do for it save the making of a speech, a conversation with my distinguished predecessor soon dispelled the dream. I found that, by the constitution of the University of Aberdeen, the incumbent of the rectorate is, if not a power, at any rate a potential energy; and that, whatever may be his chances of success or failure, it is his duty to convert that potential energy into a living force, directed toward such ends as may seem to him conducive to the welfare of the corporation of which he is the theoretical head.

[1] The Inaugural Address of the Lord Rector of the University of Aberdeen, February 27, 1874.

I need not tell you that your late lord rector took this view of his position, and acted upon it with the comprehensive, far-seeing insight into the actual condition and tendencies, not merely of his own, but of other countries, which is his honorable characteristic among statesmen. I have already done my best, and, as long as I hold my office, I shall continue to endeavor, to follow in the path which he trod; to do what in me lies to bring this university nearer to the ideal—alas! that I should be obliged to say ideal—of all universities; which, as I conceive, should be places in which thought is free from all fetters; and in which all sources of knowledge, and all aids to learning, should be accessible to all comers, without distinction of creed or country, riches or poverty.

Do not suppose, however, that I am sanguine enough to expect much to come of any poor efforts of mine. If your annals take any notice of my incumbency, I shall probably go down to posterity as the rector who was always beaten. But if they add, as I think they will, that my defeats became victories in the hands of my successors, I shall be well content.

The scenes are shifting in the great theatre of the world. The act which commenced with the Protestant Reformation is nearly played out, and a wider and a deeper change than that effected three centuries ago—a reformation, or rather a revolution of thought, the extremes of which are represented by the intellectual heirs of John of Leyden, and of Ignatius Loyola, rather than by those of Luther and of Leo—is waiting to come on, nay, visible behind the scenes to those who have good eyes. Men are beginning, once more, to awake to the fact that matters of belief and of speculation are of absolutely infinite practical importance, and are drawing off from that sunny country "where it is always afternoon"—the sleepy hollow of broad indifferentism—to range themselves under their natural banners. Change is in the air. It is whirling feather-heads into all sorts of eccentric orbits, and filling the steadiest with a sense of insecurity. It insists on reopening all questions and asking all institutions, however venerable, by what right they exist, and whether they are, or are not, in harmony with the real or supposed wants of mankind. And it is remarkable that these searching inquiries are not so much forced on institutions from without, as developed from within. Consummate scholars question the value of learning; priests contemn dogma; and women turn their back upon man's ideal of perfect womanhood, and seek satisfaction in apocalyptic visions of some, as yet unrealized, epicene reality.

If there be a type of stability in this world, one would be inclined to look for it in the old universities of England. But it has been my business, of late, to hear a good deal about what is going on in these famous corporations; and I have been filled with astonishment by the evidences of internal fermentation which they exhibit. If Gibbon could revisit the ancient seat of learning of which he has written so cavalierly, assuredly he would no longer speak of "the monks of Oxford, sunk in prejudice and port." There, as elsewhere, port has gone out of fashion, and so has prejudice—at least that particular fine, old, crusted sort of prejudice to which the great historian alludes.

Indeed, things are moving so fast in Oxford and Cambridge, that, for my part, I rejoiced when the royal commission of which I am a member had finished and presented the report which related to these universities; for, we should have looked like mere plagiarists, if, in consequence of a little longer delay in issuing it, all the measures of reform we proposed had been anticipated by the spontaneous action of the universities themselves.

A month ago, I should have gone on to say that one might speedily expect changes of another kind in Oxford and Cambridge. A commission has been inquiring into the revenues of many wealthy societies, in more or less direct connection with the universities, resident in those towns. It is said that the commission has reported, and that, for the first time in recorded history, the nation, and perhaps the colleges themselves, will know what they are worth. And it was announced that a statesman, who, whatever his other merits or defects, has aims above the level of mere party fighting, and a clear vision into the most complex, practical problems, meant to deal with these revenues.

But, *Bos locutus est.* That mysterious independent variable of political calculation, public opinion—which some whisper is, in the present case, very much the same thing as publican's opinion—has willed otherwise. The Heads may return to their wonted slumbers—at any rate for a space.

Is the spirit of change, which is working thus vigorously in the south, likely to affect the northern universities, and, if so, to what extent? The violence of fermentation depends, not so much on the quantity of the yeast, as on the composition of the wort, and its richness in fermentible material; and, as a preliminary to the discussion of this question, I venture to call to your minds the essential and fundamental differences between the Scottish and the English type of university.

Do not charge me with any thing worse than official egotism, if I say that these differences appear to be largely symbolized by my own existence. There is no rector in a English university. Now, the organization of the members of a university into nations, with their elective rector, is the last relic of the primitive constitution of universities. The rectorate was the most important of all offices in that University of Paris upon the model of which the University of Aberdeen was fashioned, and which was certainly a great and flourishing institution in the twelfth century.

Enthusiasts for the antiquity of one of the two acknowledged parents of all universities, indeed, do not hesitate to trace the origin of the "Studium Parisiense" up to that wonderful King of the Franks and Lombards, Karl, surnamed the Great, whom we all called Charlemagne, and believed to be a Frenchman, until a learned historian, by beneficent iteration, taught us better. Karl is said not to have been much of a scholar himself, but he had the wisdom of which knowledge is only the servitor. And that wisdom enabled him to see that ignorance is one of the roots of all evil.

In the "Capitulary" which enjoins the foundation of monasterial and cathedral schools, he says: "Right action is better than knowledge: but in order to do what is right we must know what is right."[1] An irrefragable truth, I fancy. Acting upon it, the king took pretty full compulsory powers, and carried into effect a really considerable and effectual scheme of elementary education through the length and breadth of his dominions.

No doubt, the idolators out by the Elbe, in what is now part of Prussia, objected to the Frankish king's measures; no doubt, the priests, who had never hesitated about sacrificing all unbelievers in their fantastic deities and futile conjurations, were the loudest in chanting the virtues of toleration; no doubt, they denounced as a cruel persecutor the man who would not allow them, however sincere they might be, to go on spreading delusions which debased the intellect, as much as they deadened the moral sense and undermined the bonds of civil allegiance; no doubt, if they had lived in these times, they would have been able to show, with ease, that the king's proceedings were totally contrary to the best liberal principles. But it may be said, in justification of the Teutonic ruler, first, that he was born before those principles, and did not suspect that the best way of getting disorder into order was to let it alone; and, secondly, that his rough and questionable proceedings did, more or less, bring about the end he had in view. For, in a couple of centuries, the schools he sowed broadcast produced their crop of men thirsting for knowledge and craving for culture. Such men, gravitating toward Paris, as a light amid the darkness of evil days, from Germany, from Spain, from Britain, and from Scandinavia, came together by natural affinity. By degrees they banded themselves into a society, which, as its end was the knowledge of all things knowable, called itself a "*Studium Generale*;" and, when it had grown into a recognized corporation, acquired the name of "*Universitas Studii Generalis*;" which, mark you, means not a "Useful Knowledge Society," but a "Knowledge-of-things-in-general Society."

[1] "Quamvis enim melius sit bene facere quam nosse, prius tamen est nosse quam facere."—"Karoli Magni Regis Constitutio de Scholis per singula Episcopia et Monasteria instituendis," addressed to the Abbot of Fulda. Baluzius, "Capitularia Regum Francorum," tomus i., p. 202.

And thus the first "university," at any rate on this side of the Alps, came into being. Originally it had but one faculty, that of arts. Its aim was, to be a centre of knowledge and culture, not to be, in any sense, a technical school.

The scholars seemed to have studied grammar, logic, and rhetoric; arithmetic and geometry; astronomy; theology; and music. Thus, their work, however imperfect and faulty, judged by modern lights, it may have been, brought them face to face with all the leading aspects of the many-sided mind of man. For these studies did really contain, at any rate, in embryo—sometimes, it may be, in caricature—what we now call philosophy, mathematical and physical science, and art. And I doubt if the curriculum of any modern university shows so clear and generous a comprehension of what is meant by culture as this old *trivium* and *quadrivium* does.

The students who had passed through the university course, and had proved themselves competent to teach, became masters and teachers of their younger brethren. Whence the distinction of masters and regents, on the one hand, and scholars, on the other.

Rapid growth necessitated organization. The masters and scholars, of various tongues and countries, grouped themselves into four nations; and the nations, by their own votes at first, and subsequently by those of their procurators, or representatives, elected their supreme head and governor, the rector—at that time the sole representative of the university, and a very real power, who could defy provosts interfering from without, or could inflict even corporal punishment on disobedient members within the university.

Such was the primitive constitution of the University of Paris. It is in reference to this original state of things, that I have spoken of the rectorate, and all that appertains to it, as the sole relic of that constitution.

But this original organization did not last long. Society was not then, any more than it is now, patient of culture, as such. It says to every thing, "Be useful to me, or away with you." And, to the learned, the unlearned man said then, as he does now: "What is the use of all your learning, unless you can tell me what I want to know? I am here blindly groping about, and constantly damaging myself by collision with three mighty powers: the power of the invisible God, the power of my fellow-man, and the power of brute Nature. Let your learning be turned to the study of these powers, that I may know how I am to comport myself with regard to them." In answer to this demand, some of the masters of the faculty of arts devoted themselves to the study of theology, some to that of law, and some to that of medicine; and they became doctors—men learned in those technical, or, as we now call them, professional branches of knowledge. Like cleaving to like, the doctors formed schools, or faculties, of theology, law, and medicine, which sometimes assumed airs of superiority over their parent, the faculty of arts, though the latter always asserted and maintained its fundamental supremacy.

The faculties arose, by process of natural differentiation, out of the primitive university. Other constituents, foreign to its nature, were speedily grafted upon it. One of these extraneous elements was forced into it by the Roman Church, which in those days asserted with effect, that which it now asserts, happily without any effect in these realms, its right of censorship and control over all teaching. The local habitation of the university lay partly in the lands attached to the monastery of St. Geneviève, partly in the diocese of the Bishop of Paris; and he who would teach must have the license of the abbot, or of the bishop, as the nearest representative of the pope, so to do; which license was granted by the chancellors of these ecclesiastics.

Thus, if I am what archæologists call a "survival" of the primitive head and ruler of the university, your chancellor stands in the same relation to the papacy—and, with all respect for his grace, I think I may say that we both look terribly shrunken when compared with our great originals.

Not so is it with a second foreign element, which silently dropped into the soil of universities like the grain of mustard-seed in the parable; and, like that grain, grew into a tree in whose branches a whole aviary of fowls took shelter. That element is the element of endowment. It differed from the preceding, in its original design to serve as a prop to the young plant, not to be a parasite upon it. The charitable and the humane, blessed with wealth, were very early penetrated by the misery of the poor student. And the wise saw that intellectual ability is not so common, or so unimportant a gift, that it should be allowed to run to waste upon mere handicrafts and chares. The man who was a blessing to his contemporaries, but who so often has been converted into a curse, by the blind adherence of his posterity to the letter, rather than to the spirit, of his wishes—I mean the "pious founder"—gave money and lands, that the student who was rich in brain and poor in all else might be taken from the plough or from the stithy, and enabled to devote himself to the higher service of mankind; and built colleges and halls in which he might be not only housed and fed, but taught.

The colleges were very generally placed in strict subordination to the university by their founders; but, in many cases, their endowment, consisting of land, has undergone an "unearned increment," which has given these societies a continually-increasing weight and importance as against the unendowed, or fixedly-endowed university. In Pharaoh's dream, the seven lean kine eat up the seven fat ones. In the reality of historical fact, the fat colleges have eaten up the lean universities.

Even here in Aberdeen, though the causes at work may have been somewhat different, the effects have been similar; and you see how much more substantial an entity is the very reverend the principal, analogue, if not homologue, of the principals of King's College, than the rector, lineal representative of the ancient monarchs of the university, though, now, little more than a "king of shreds and patches."

Do not suppose that, in thus briefly tracing the process of university metamorphosis, I have had any intention of quarreling with its results. Practically, it seems to me that the broad changes effected in 1858 have given the Scottish universities a very liberal constitution, with as much real approximation to the primitive state of things as is at all desirable. If your fat kine have eaten the lean, they have not lain down to chew the cud ever since. The Scottish universities, like the English, have diverged widely enough from their primitive model; but I cannot help thinking that the northern form has remained more faithful to its original, not only in constitution, but, what is more to the purpose, in view of the cry for change, in the practical application of the endowments connected with it.

In Aberdeen, these endowments are numerous, but so small that, taken altogether, they are not equal to the revenue of a single third-rate English college. They are scholarships, not fellowships; aids to do work—not rewards for such work, as it lies within the reach of an ordinary, or even an extraordinary, young man to do. You do not think that passing a respectable examination is a fair equivalent for an income, such as many a gray-headed veteran or clergyman would envy; and which is larger than the endowment of many regius chairs. You do not care to make your university a school of manners for the rich; of sports for the athletic; or a hot-bed of high-fed, hypercritical refinement, more destructive to vigor and originality than are starvation and oppression. No; your little bursaries of ten and twenty (I believe even fifty) pounds a year, enable any boy who has shown ability—in the course of his education in those remarkable primary schools which have made Scotland the power she is—to obtain the highest culture the country can give him; and, when he is armed and equipped, his Spartan alma mater tells him that, so far, he has had his wages for his work, and that he may go and earn the rest.

When I think of the host of pleasant, moneyed, well-bred young gentlemen, who do a little learning and much boating by Cam and Isis, the vision is a pleasant one; and, as a patriot, I rejoice that the youth of the upper and richer classes of the nation receive a wholesome and a manly training, however small may be the modicum of knowledge they gather, in the intervals of this, their serious business. I admit, to the full, the social and political value of that training. But, when I proceed to consider that these young men may be said to represent the great bulk of what the colleges have to show for their enormous wealth, *plus*, at least, a hundred and fifty pounds a year apiece, which each undergraduate costs his parents or guardians, I feel inclined to ask, whether the rate-in-aid of the education of the wealthy and professional classes, thus levied on the resources of the community, is not, after all, a little heavy? And, still further, I am tempted to inquire what has become of the indigent scholars, the sons of the masses of the people, whose daily labor just suffices to meet their daily wants, for whose benefit these rich foundations were largely if not mainly instituted? It seems as if Pharaoh's dream had been rigorously carried out, and that even the fat scholar has eaten the lean one. And, when I turn from this picture to the no less real vision of many a brave and frugal Scotch boy, spending his summer in hard manual labor, that he may have the privilege of wending his way in autumn to this university, with a bag of oatmeal, ten pounds in his pocket, and his own stout heart to depend upon through the northern winter; not bent on seeking

"The bubble reputation at the cannon's mouth,"

but determined to wring knowledge from the hard hands of penury; when I see him win through all such outward obstacles to positions of wide usefulness and well-earned fame—I cannot but think that, in essence, Aberdeen has departed but little from the primitive intention of the founders of universities, and that the spirit of reform has so much to do on the other side of the border, that it may be long before he has leisure to look this way.

As compared with other actual universities, then, Aberdeen may, perhaps, be well satisfied with itself. But, do not think me an impracticable dreamer, if I ask you not to rest and be thankful in this state of satisfaction; if I ask you to consider, awhile, how this actual good stands related to that ideal better toward which both men and institutions must progress, if they would not retrograde.

In an ideal university, as I conceive it, a man should be able to obtain instruction in all forms of knowledge, and discipline in the use of all the methods by which knowledge is obtained. In such a university, the force of living example should fire the student with a noble ambition to emulate the learning of learned men, and to follow in the footsteps of the explorers of new fields of knowledge. And the very air he breathes should be charged with that enthusiasm for truth, that fanaticism of veracity, which is a greater possession than much learning; a nobler gift than the power of increasing knowledge; by so much greater and nobler than these, as the moral nature of man is greater than the intellectual—for veracity is the heart of morality.

But the man who is all morality and intellect, although he may be good and even great, is, after all, only half a man. There is beauty in the moral world and in the intellectual world; but there is also a beauty which is neither moral nor intellectual—the beauty of the world of art. There are men who are devoid of the power of seeing it, as there are men who are born deaf and blind, and the loss of those, as of these, is simply infinite. There are others in whom it is an overpowering passion; happy men, born with the productive, or, at lowest, the appreciative, genius of the artist. But, in the mass of mankind, the æsthetic faculty, like the reasoning power and the moral sense, needs to be roused, directed, and cultivated; and I know not why the development of that side of his nature, through which man has access to a perennial spring of ennobling pleasure, should be omitted from any comprehensive scheme of university education.

All universities recognize literature in the sense of the old rhetoric, which is art incarnate in words. Some, to their credit, recognize art in its narrower sense, to a certain extent, and confer degrees for proficiency in some of its branches. If there are doctors of music, why should there be no masters of painting, of sculpture, of architecture? I should like to see professors of the fine arts in every university; and instruction in some branch of their work made a part of the arts curriculum.

I just now expressed the opinion that, in our ideal university, a man should be able to obtain instruction in all forms of knowledge. Now, by "forms of knowledge" I mean the great classes of things knowable; of which the first, in logical, though not in natural, order is knowledge relating to the scope and limits of the mental faculties of man; a form of knowledge which, in its positive aspect, answers pretty much to logic and part of psychology, while, on its negative and critical side, it corresponds with metaphysics.

A second class comprehends all that knowledge which relates to man's welfare, so far as it is determined by his own acts, or what we call his conduct. It answers to moral and religious philosophy. Practically, it is the most directly valuable of all forms of knowledge, but, speculatively, it is limited and criticised by that which precedes and by that which follows it in my order of enumeration.

A third class embraces knowledge of the phenomena of the universe, as that which lies about the individual man; and of the rules which those phenomena are observed to follow in the order of their occurrence, which we term the laws of Nature.

This is what ought to be called natural science, or physiology, though those terms are hopelessly diverted from such a meaning; and it includes all exact knowledge of natural fact, whether mathematical, physical, biological, or social.

Kant has said that the ultimate object of all knowledge is to give replies to these three questions: What can I do? What ought I to do? What may I hope for? The forms of knowledge which I have enumerated should furnish such replies as are within human reach, to the first and second of these questions. While to the third, perhaps, the wisest answer is, "Do what you can to do what you ought, and leave hoping and fearing alone."

If this be a just and an exhaustive classification of the forms of knowledge, no question as to their relative importance, or as to the snperiority of one to the other, can be seriously raised.

On the face of the matter, it is absurd to ask whether it is more important to know the limits of one's powers; or the ends for which they ought to be exerted; or the conditions under which they must be exerted. One may as well inquire which of the terms of a rule-of-three sum one ought to know, in order to get a trustworthy result. Practical life is such a sum, in which your duty multiplied into your capacity, and divided by your circumstances, gives you the fourth term in the proportion, which is your deserts, with great accuracy. All agree, I take it, that men ought to have these three kinds of knowledge. The so-called "conflict of studies" turns upon the question of how they may best be obtained.

The founders of universities held the theory that the Scriptures and Aristotle taken together, the latter being limited by the former, contained all knowledge worth having, and that the business of philosophy was to interpret and coördinate these two. I imagine that in the twelfth century this was a very fair conclusion from known facts. Nowhere in the world, in those days, was there such an encyclopædia of knowledge of all three classes as is to be found in those writings. The scholastic philosophy is a wonderful monument of the patience and ingenuity with which the human mind toiled to build up a logically consistent theory of the universe, out of such materials. And that philosophy is by no means dead and buried, as many vainly suppose. On the contrary, numbers of men of no mean learning and accomplishment, and sometimes of rare power and subtilty of thought, hold by it as the best theory of things which has yet been stated. And, what is still more remarkable, men who speak the language of modern philosophy nevertheless think the thoughts of the schoolmen. "The voice is the voice of Jacob, but the hands are the hands of Esau." Every day I hear "Cause," "Law," "Force," "Vitality," spoken of as entities, by people who can enjoy Swift's joke about the meat-roasting quality of the smoke-jack, and comfort themselves with the reflection that they are not even as those benighted schoolmen.

Well, this great system had its day, and then it was sapped and mined by two influences. The first was, the study of classical literature, which familiarized men with methods of philosophizing; with conceptions of the highest good; with ideas of the order of Nature; with notions of literary and historical criticism; and, above all, with visions of art, of a kind which not only would not fit into the scholastic scheme, but showed them a pre-Christian, and indeed altogether un-Christian world, of such grandeur and beauty that they ceased to think of any other. They were as men who had kissed the fairy queen, and, wandering with her in the dim loveliness of the under-world, cared not to return to the familar ways of home and father-land, though they lay, at arm's-length, overhead. Cardinals were more familiar with Virgil than with Isaiah; and popes labored, with great success, to repaganize Rome.

The second influence was the slow, but sure, growth of the physical sciences. It was discovered that some results of speculative thought, of immense practical and theoretical importance, can be verified by observation; and are always true, however severely they may be tested. Here, at any rate, was knowledge, to the certainty of which no authority could add, or take away, one jot or tittle, and to which the tradition of a thousand years was as insignificant as the hearsay of yesterday. To the scholastic system, the study of classical literature might be inconvenient and distracting, but it was possible to hope that it could be kept within bounds. Physical science, on the other hand, was an irreconcilable enemy, to be excluded at all hazards. The College of Cardinals has not distinguished itself in physics or physiology; and no pope has, as yet, set up public laboratories in the Vatican.

People do not always formulate the beliefs on which they act. The instinct of fear and dislike is quicker than the reasoning process; and I suspect that, taken in conjunction with some other causes, such instinctive aversion is at the bottom of the long exclusion of any serious discipline in the physical sciences from the general curriculum of universities; while, on the other hand, classical literature has been gradually made the backbone of the arts course.

I am ashamed to repeat here what I have said elsewhere, in season and out of season, respecting the value of science as knowledge and discipline. But the other day I met with some passages in the address to another Scottish university, of a great thinker, recently lost to us, which express so fully, and yet so tersely, the truth in this matter, that I am fain to quote them:

"To question all things—never to turn away from any difficulty; to accept no doctrine either from ourselves or from other people without a rigid scrutiny by negative criticism; letting no fallacy, or incoherence, or confusion of thought step by unperceived; above all, to insist upon having the meaning of a word clearly understood before using it, and the meaning of a proposition before assenting to it—these are the lessons we learn" from workers in science. "With all this vigorous management of the negative element, they inspire no skepticism about the reality of truth or indifference to its pursuit. The noblest enthusiasm, both for the search after truth and for applying it to its highest uses, pervades those writers. . . . In cultivating, therefore," science as an essential ingredient in education, "we are all the while laying an admirable foundation for ethical and philosophical culture." [1]

[1] Inaugural address delivered to the University of St. Andrews, February 1, 1867, by J. S. Mill, Rector of the University (pp. 32, 33).

The passages I have quoted were uttered by John Stuart Mill; but you cannot hear inverted commas, and it is therefore right that I should add, without delay, that I have taken the liberty of substituting "workers in science" for "ancient dialecticians," and "science as an essential ingredient in education" for "the ancient languages as our best literary education." Mill did, in fact, deliver a noble panegyric upon classical studies. I do not doubt its justice, nor presume to question its wisdom. But I venture to maintain that no wise or just judge, who has a knowledge of the facts, will hesitate to say that it applies with equal force to scientific training.

But it is only fair to the Scottish universities to point out that they have long understood the value of science as a branch of general education. I observe, with the greatest satisfaction, that candidates for the degree of Master of Arts in this university are required to have a knowledge, not only of mental and moral philosophy, and of mathematics and natural philosophy, but of natural history, in addition to the ordinary Latin and Greek course; and that a candidate may take honors in these subjects and in chemistry.

I do not know what the requirements of your examiners may be, but I sincerely trust they are not satisfied with a mere book-knowledge of these matters. For my own part, I would not raise a finger, if I could thereby introduce mere book-work in science into every arts curriculum in the country. Let those who want to study books devote themselves to literature, in which we have the perfection of books, both as to substance and as to form. If I may paraphrase Hobbes's well-known aphorism, I would say that "books are the money of literature, but only the counters of science," science (in the sense in which I now use the term) being the knowledge of fact, of which every verbal description is but an incomplete and symbolic expression. And be assured that no teaching of science is worth any thing, as a mental discipline, which is not based upon direct perception of the facts, and practical exercise of the observing and logical faculties upon them. Even in such a simple matter as the mere comprehension of form, ask the most practised and widely-informed anatomist what is the difference between his knowledge of a structure which he has read about and his knowledge of the same structure when he has seen it for himself, and he will tell you that the two things are not comparable — the difference is infinite. Thus I am very strongly inclined to agree with some learned school-masters who say that, in their experience, the teaching of science is all waste time. As they teach it, I have no doubt it is. But, to teach it otherwise, requires an amount of personal labor and a development of means and appliances, which must strike horror and dismay into a man accustomed to mere book-work, and who has been in the habit of teaching a class of fifty without much strain upon his energies. And this is one of the real difficulties in the way of the introduction of physical science into the ordinary university course, to which I have alluded. It is a difficulty which will not be overcome, until years of patient study have organized scientific teaching as well as, or I hope better than, classical teaching has been organized hitherto.

A little while ago, I ventured to hint a doubt as to the perfection of some of the arrangements in the ancient universities of England; but, in their provision for giving instruction in science as such, and without direct reference to any of its practical applications, they have set a brilliant example. Within the last twenty years, Oxford alone has sunk more than a hundred and twenty thousand pounds in building and furnishing physical, chemical, and physiological laboratories, and a magnificent museum, arranged with an almost luxurious regard for the needs of the student. Cambridge, less rich, but aided by the munificence of her chancellor, is taking the same course; and, in a few years, it will be for no lack of the means and appliances of sound teaching, if the mass of English university men remain in their present state of barbarous ignorance of even the rudiments of scientific culture.

Yet another step needs to be made before science can be said to have taken its proper place in the universities. That is its recognition as a faculty, or branch of study demanding recognition and special organization, on account of its bearing on the wants of mankind. The faculties of theology, law, and medicine, are technical schools, intended to equip men, who have received general culture, with the special knowledge which is needed for the proper performance of the duties of clergymen, lawyers, and medical practitioners.

When the material well-being of the country depended upon rude pasture and agriculture, and still ruder mining; in the days when all the innumerable applications of the principles of physical science to practical purposes were non-existent even as dreams—days which men living may have heard their fathers speak of—what little physical science could be seen to bear directly upon human life lay within the province of medicine. Medicine was the foster-mother of chemistry, because it has to do with the preparation of drugs and the detection of poisons; of botany, because it enabled the physician to recognize medicinal herbs; of comparative anatomy and physiology, because the man who studied human anatomy and physiology for purely medical purposes was led to extend his studies to the rest of the animal world.

Within my recollection, the only way in which a student could obtain any thing like a training in physical science was, by attending the lectures of the professors of physical and natural science attached to the medical schools. But, in the course of the last thirty years, both foster-mother and child have grown so big, that they threaten not only to crush one another, but to press the very life out of the unhappy student who enters the nursery; to the great detriment of all three.

I speak in the presence of those who know practically what medical education is; for I may assume that a large proportion of my hearers are more or less advanced students of medicine. I appeal to the most industrious and conscientious among you, to those who are most deeply penetrated with a sense of the extremely serious responsibilities which attach to the calling of a medical practitioner, when I ask whether, out of the four years which you devote to your studies, you ought to spare even so much as an hour for any work which does not tend directly to fit you for your duties?

Consider what that work is. Its foundation is a sound and practical acquaintance with the structure of the human organism, and with the modes and conditions of its action in health. I say a sound and practical acquaintance, to guard against the supposition that my intention is to suggest that you ought all to be minute anatomists and accomplished physiologists. The devotion of your whole four years to anatomy and physiology alone would be totally insufficient to attain that end. What I mean is, the sort of practical, familiar, finger-end knowledge which a watchmaker has of a watch, and which you expect that craftsman, as an honest man, to have, when you intrust a watch, that goes badly, to him. It is a kind of knowledge which is to be acquired, not in the lecture-room, nor in the study, but in the dissecting-room and the laboratory. It is to be had, not by sharing your attention between these and sundry other subjects, but by concentrating your minds, week after week, and month after month, six or seven hours a day, upon all the complexities of organ and function, until each of the greater truths of anatomy and physiology has become an organic part of your minds—until you would know them if you were roused and questioned in the middle of the night, as a man knows the geography of his native place and the daily life of his home. That is the sort of knowledge which, once obtained, is a life-long possession. Other occupations may fill your minds—it may grow dim, and seem to be forgotten—but there it is, like the inscription on a battered and defaced coin, which comes out when you warm it.

If I had the power to remodel medical education, the first two years of the medical curriculum should be devoted to nothing but such thorough study of anatomy and physiology, with physiological chemistry and physics; the student should then pass a real, practical examination in these subjects; and, having gone through that ordeal satisfactorily, he should be troubled no more with them. His whole mind should then be given, with equal intentness, to therapeutics, in its broadest sense, to practical medicine and to surgery, with instruction in hygiene and in medical jurisprudence; and of these subjects only—surely there are enough of them—should he be required to show a knowledge in his final examination.

I cannot claim any special property in this theory of what the medical curriculum should be, for I find that views, more or less closely approximating these, are held by all who have seriously considered the very grave and pressing question of medical reform; and have, indeed, been carried into practice, to some extent, by the most enlightened examining boards. I have heard but two kinds of objections to them. There is, first, the objection of vested interests, which I will not deal with here, because I want to make myself as pleasant as I can, and no discussions are so unpleasant as those which turn on such points. And there is, secondly, the much more respectable objection, which takes the general form of the reproach that, in thus limiting the curriculum, we are seeking to narrow it. We are told that the medical man ought to be a person of good education and general information, if his profession is to hold its own among other professions; that he ought to know botany, or else, if he goes abroad, he won't be able to tell poisonous fruits from edible ones; that he ought to know drugs, as a druggist knows them, or he won't be able to tell sham bark and senna from the real articles; that he ought to know zoology, because—well, I really have never been able to learn exactly why he is to be expected to know zoology. There is, indeed, a popular superstition, that doctors know all about things that are queer or nasty to the general mind, and may, therefore, be reasonably expected to know the "barbarous binomials" applicable to snakes, snails, and slugs; an amount of information with which the general mind is usually completely satisfied. And there is a scientific superstition that physiology is largely aided by comparative anatomy—a superstition which, like most, once had a grain of truth at bottom; but the grain has become homœopathic, since physiology took its modern experimental development, and became what it is now—the application of the principles of physics and chemistry to the elucidation of the phenomena of life.

I hold as strongly as any one can do, that the medical practitioner ought to be a person of education and good general culture; but I also hold by the old theory of a faculty, that a man should have his general culture before he devotes himself to the special studies of that faculty; and I venture to maintain that, if the general culture obtained in the faculty of arts were what it ought to be, the student would have quite as much knowledge of the fundamental principles of physics, of chemistry, and of biology, as he needs, before he commenced his special medical studies.

Moreover, I would urge that a thorough study of human physiology is, in itself, an education broader and more comprehensive than much that passes under that name. There is no side of the intellect which it does not call into play, no region of human knowledge into which either its roots, or its branches, do not extend; like the Atlantic between the Old and the New Worlds, its waves wash the shores of the two worlds of matter and of mind; its tributary streams flow from both; through its waters, as yet unfurrowed by the keel of any Columbus, lies the road, if such there be, from the one to the other; far away from that Northwest passage of mere speculation, in which so many brave souls have been hopelessly frozen up.

But, whether I am right or wrong about all this, the patent fact of the limitation of time remains. As the song runs:

> "If a man could be sure
> That his life would endure
> For the space of a thousand long years—"

he might do a number of things not practicable under present conditions. Methuselah might, with much propriety, have taken half a century to get his doctor's degree; and might, very fairly, have been required to pass a practical examination upon the contents of the British Museum, before commencing practice as a promising young fellow of two hundred, or thereabouts. But you have four years to do your work in, and are turned loose, to save or slay, at two or three and twenty.

Now, I put it to you, whether you think that, when you come down to the realities of life—when you stand by the sick-bed, racking your brains for the principles which shall furnish you with the means of interpreting symptoms, and forming a rational theory of the condition of your patient—it will be satisfactory for you to find that those principles are not there, but that, to use the examination slang which is unfortunately too familiar to me, you can quite easily "give an account of the leading peculiarities of the *Marsupialia*," or "enumerate the chief characters of the *Compositæ*," or "state the class and order of the animal from which castoreum is obtained."

I really do not think that state of things will be satisfactory to you; I am very sure it will not be so to your patient. Indeed, I am so narrow-minded myself, that if I had to choose between two physicians—one who did not know whether a whale was a fish or not, and could not tell gentian from ginger, but did understand the applications of the institutes of medicine to his art; while the other, like Talleyrand's doctor, "knew every thing, even a little physic"—with all my love for breadth of culture, I should assuredly consult the former.

It is not pleasant to incur the suspicion of an inclination to injure or depreciate particular branches of knowledge. But the fact, that one of those which I should have no hesitation in excluding from the medical curriculum is that to which my own life has been specially devoted, should, at any rate, defend me from the suspicion of being urged to this course by any but the very gravest considerations of the public welfare.

And I should like, further, to call your attention to the important circumstance that, in thus proposing the exclusion of the study of such branches of knowledge as zoology and botany, from those compulsory upon the medical student, I am not, for a moment, suggesting their exclusion from the university. I think that sound and practical instruction in the elementary facts and broad principles of biology should form part of the arts curriculum: and here, happily, my theory is in entire accordance with your practice. Moreover, as I have already said, I have no sort of doubt that, in view of the relation of physical science to the practical life of the present day, it has the same right as theology, law, and medicine, to a faculty of its own in which men shall be trained to be professional men of science. It may be doubted whether universities are the places for technical schools of engineering, or applied chemistry, or agriculture. But there can surely be little question, that instruction in the branches of science which lie at the foundation of these arts, of a far more advanced and special character than could, with any propriety, be included in the ordinary arts curriculum, ought to be obtainable by means of a duly-organized faculty of science in every university.

The establishment of such a faculty would have the additional advantage of providing, in some measure, for one of the greatest wants of our time and country. I mean the proper support and encouragement of original research.

The other day, an emphatic friend of mine committed himself to the opinion that, in England, it is better for a man's worldly prospects to be a drunkard, than to be smitten with the divine dipsomania of the original investigator. I am inclined to think he was not far wrong. And, be it observed, that the question is not, whether such a man shall be able to make as much out of his abilities as his brother, of like ability, who goes into law, or engineering, or commerce; it is not a question of "maintaining a due number of saddle-horses," as George Eliot somewhere puts it—it is a question of living or starving.

If a student of my own subject shows power and originality, I dare not advise him to adopt a scientific career; for, supposing he is able to maintain himself until he has attained distinction, I cannot give him the assurance that any amount of proficiency in the biological sciences will be convertible into, even the most modest, bread-and-cheese. And I believe that the case is as bad, or perhaps worse, with other branches of science. In this respect Britain, whose immense wealth and prosperity hang upon the thread of applied science, is far behind France, and infinitely behind Germany.

And the worst of it is, that it is very difficult to see one's way to any immediate remedy for this state of affairs which shall be free from a tendency to become worse than the disease.

Great schemes for the endowment of research have been proposed. It has been suggested that laboratories for all branches of physical science, provided with every apparatus needed by the investigator, shall be established by the state; and shall be accessible, under due conditions and regulations, to all properly-qualified persons. I see no objection to the principle of such a proposal. If it be legitimate to spend great sums of money on public libraries and public collections of painting and sculpture, in aid of the man of letters, or the artist, or for the mere sake of affording pleasure to the general public, I apprehend that it cannot be illegitimate to do as much for the promotion of scientific investigation. To take the lowest ground, as a mere investment of money, the latter is likely to be much more immediately profitable. To my mind, the difficulty in the way of such schemes is not theoretical, but practical. Given the laboratories, how are the investigators to be maintained? What career is open to those who have been thus encouraged to leave bread-winning pursuits? If they are to be provided for by endowment, we come back to the college fellowship system, the results of which, for literature, have not been so brilliant that one would wish to see it extended to science; unless some much better securities, than at present exist, can be taken that it will foster real work. You know that, among the bees, it depends on the kind of cell in which the egg is deposited, and the quantity and quality of food which is supplied to the grub, whether it shall turn out a busy little worker or a big idle queen. And, in the human hive, the cells of the endowed larvæ are always tending to enlarge, and their food to improve, until we get queens, beautiful to behold, but which gather no honey and build no comb.

I do not say that these difficulties may not be overcome, but their gravity is not to be lightly estimated.

In the mean while, there is one step in the direction of the endowment of research which is free from such objections. It is possible to place the scientific inquirer in a position in which he shall have ample leisure and opportunity for original work, and yet shall give a fair and tangible equivalent for those privileges. The establishment of a faculty of science in every university, implies that of a corresponding number of professional chairs, the incumbents of which need not be so burdened with teaching as to deprive them of ample leisure for original work. I do not think that it is any impediment to an original investigator to have to devote a moderate portion of his time to lecturing, or superintending practical instruction. On the contrary, I think it may be, and often is, a benefit to be obliged to take a comprehensive survey of your subject; or to bring your results to a point, and give them, as it were, a tangible objective existence. The besetting sins of the investigator are two: the one is the desire to put aside a subject, the general bearings of which he has mastered himself, and pass on to something which has the attraction of novelty; and the other, the desire for too much perfection, which leads him to

> "Add and alter many times,
> Till all be ripe and rotten;"

to spend the energies which should be reserved for action, in whitening the decks and polishing the guns.

The necessity for producing results for the instruction of others, seems to me to be a more effectual check on these tendencies, than even the love of usefulness or the ambition for fame.

But supposing the professorial forces of our university to be duly organized, there remains an important question, relating to the teaching power, to be considered. Is the professorial system—the system, I mean, of teaching in the lecture-room alone, and leaving the student to find his own way when he is outside of the lecture-room—adequate to the wants of learners? In answering this question, I confine myself to my own province, and I venture to reply for physical science, assuredly and undoubtedly, No. As I have already intimated, practical work in the laboratory is absolutely indispensable, and that practical work must be guided and superintended by a sufficient staff of demonstrators, who are for science what tutors are for other branches of study. And there must be a good supply of such demonstrators. I doubt if the practical work of more than twenty students can be properly superintended by one demonstrator—if we take the working-day at six hours, that is, twenty minutes apiece—not a very large allowance of time for helping a dull man, for correcting an inaccurate one, or even for making an intelligent student clearly apprehend what he is about. And, no doubt, the supplying of a proper amount of this tutorial, practical teaching is a difficulty in the way of giving proper instruction in physical science in such universities as that of Aberdeen, which are devoid of endowments; and, unlike the English universities, have no moral claim on the funds of richly-endowed bodies to supply their wants.

Examination—thorough, searching examination—is an indispensable accompaniment of teaching; but I am almost inclined to commit myself to the very heterodox proposition that it is a necessary evil. I am a very old examiner, having, for some twenty years past, been occupied with examinations on a considerable scale, of all sorts and conditions of men, and women too—from the boys and girls of elementary schools, to the candidates for honors and fellowships in the universities. I will not say that, in this case, as in so many others, the adage that familiarity breeds contempt holds good; but my admiration for the existing system of examination, and its products, does not wax warmer as I see more of it. Examination, like fire, is a good servant, but a bad master; and there seems to me to be some danger of its becoming our master. I by no means stand alone in this opinion. Experienced friends of mine do not hesitate to say that students whose career they watch, appear to them to become deteriorated by the constant effort to pass this or that examination, just as we hear of men's brains becoming affected by the daily necessity of catching a train. They work to pass, not to know; and outraged Science takes her revenge. They do pass, and they don't know. I have passed sundry examinations in my time, not without credit, and I confess I am ashamed to think how very little real knowledge underlay the torrent of stuff which I was able to pour out on paper. In fact, that which examination, as ordinarily conducted, tests, is simply a man's power of work under stimulus, and his capacity for rapidly and clearly producing that which, for the time, he has got into his mind. Now, these faculties are by no means to be despised. They are of great value in practical life, and are the making of many an advocate, and of many a so-called statesman. But, in the pursuit of truth, scientific or other, they count for very little, unless they are supplemented by that long-continued, patient "intending of the mind" as Newton phrased it, which makes very little show in examinations. I imagine that an examiner, who knows his students personally, must not unfrequently have found himself in the position of finding A's paper better than B's, though his own judgment tells him, quite clearly, that B is the man who has the larger share of genuine capacity.

Again, there is a fallacy about examiners. It is commonly supposed that any one who knows a subject is competent to teach it; and no one seems to doubt that any one who knows a subject is competent to examine in it. I believe both these opinions to be serious mistakes; the latter, perhaps, the more serious of the two. In the first place, I do not believe that any one who is not, or has not been a teacher, is really qualified to examine advanced students. And, in the second place, examination is an art, and a difficult one, which has to be learned like all other arts.

Beginners always set too difficult questions—partly because they are afraid of being suspected of ignorance if they set easy ones, and partly from not understanding their business. Suppose that you want to test the relative physical strength of a score of young men. You do not put a hundred-weight down before them, and tell each to swing it round. If you do, half of them won't be able to lift it at all, and only one or two will be able to perform the task. You must give them half a hundred-weight, and see how they manœuvre that, if you want to form any estimate of the muscular strength ef each. So, a practised examiner will seek for information respecting the mental vigor and training of candidates from the way in which they deal with questions easy enough to let reason, memory, and method, have free play.

No doubt, a great deal is to done by the careful selection of examiners, and by the copious introduction of practical work, to remove the evils inseparable from examination; but, under the best of circumstances, I believe that examination will remain but an imperfect test of knowledge, and a still more imperfect test of capacity, while it tells next to nothing about a man's power as an investigator.

There is much to be said in favor of restricting the highest degrees, in each faculty, to those who have shown evidence of such original power, by prosecuting a research under the eye of the professor in whose province it lies; or, at any rate, under conditions which shall afford satisfactory proof that the work is theirs. The notion may sound revolutionary, but it is really very old—for, I take it, that it lies at the bottom of that presentation of a thesis by the candidate for a doctorate, which has now too often become little better than a matter of form.

Thus far, I have endeavored to lay before you, in a too brief and imperfect manner, my views respecting the teaching half—the *magistri* and *regentes*—of the university of the future. Now let me turn to the learning half—the *scholares*.

If the universities are to be the sanctuaries of the highest culture of the country—those who would enter that sanctuary must not come with unwashed hands. If the good seed is to yield its hundred-fold harvest, it must not be scattered amid the stones of ignorance, or the tares of undisciplined indolence and wantonness. On the contrary, the soil must have been carefully prepared, and the professor should find that the operations of clod-crushing, draining, and weeding, and even a good deal of planting, have been done by the school-master.

That is exactly what the professor does not find in any university in the three kingdoms that I can hear of—the reason of which state of things lies in the extremely faulty organization of the majority of secondary schools. Students come to the universities ill-prepared in classics and mathematics, not at all prepared in any thing else; and half their time is spent in learning that which they ought to have known when they came.

I sometimes hear it said that the Scottish universities differ from the English in being to a much greater extent places of comparatively elementary education for a younger class of students. But it would seem doubtful if any great difference of this kind really exists; for a high authority, himself head of an English college, has solemnly affirmed that "elementary teaching of youths under twenty is now the only function performed by the university;" and that colleges are "boarding-schools in which the elements of the learned languages are taught to youths."[1]

This is not the first time that I have quoted those remarkable assertions. I should like to engrave them in public view, for they have not been refuted; and I am convinced that, if their import is once clearly apprehended, they will play no mean part when the question of university reorganization, with a view to practical measures, comes on for discussion. You are not responsible for this anomalous state of affairs now; but, as you pass into active life, and acquire the political influence to which your education and your position should entitle you, you will become responsible for it, unless each in his

[1] "Suggestions for Academical Organization, with Especial Reference to Oxford." By the Rector of Lincoln.

sphere does his best to alter it, by insisting on the improvement of secondary schools.

Your present responsibility is of another, though not less serious, kind. Institutions do not make men, any more than organization makes life; and even the ideal university we have been dreaming about will be but a superior piece of mechanism, unless each student strive after the ideal of the scholar. And that ideal, it seems to me, has never been better embodied than by the great poet, who, though lapped in luxury, the favorite of a court, and the idol of his countrymen, remained, through all the length of his honored years, a scholar in art, in science, and in life:

"Wouldst shape a noble life? Then cast
No backward glances toward the past:
And though somewhat be lost and gone,
Yet do thou act as one new-born.
What each day needs, that shalt thou ask;
Each day will set its proper task.
Give others' work just share of praise;
Not of thine own the merits raise.
Beware no fellow-man thou hate:
And so in God's hands leave thy fate."

—*Contemporary Review.*

ACTION OF SUNLIGHT ON GLASS.

By E. S. DRONE.

IN a quiet street at the "West End" of Boston, there stands a house, the window-sills and roof of which, for more than ten years, have been covered with hundreds of pieces of glass, exposed to the full force of the sun's rays during the whole or greater portion of every day, only being protected by covers in the event of snow-storms. The results of these experiments, instituted to show a change produced in the color of glass by the actinic rays of the sun, have been discussed in this country and in Europe, but as yet the cause of this remarkable phenomenon has not been fully explained.

As early as 1825, Prof. Faraday noticed a change of color in glass containing oxide of manganese, due to the action of solar light, and it was thought that advantage might in some cases be taken of this action for the removal of color in glass. Prof. Faraday found that glass of a pale color, or even colorless at first, became pink by long exposure to solar rays, while portions of the same glass, not so exposed, were apparently unaltered. This effect he attributed to the solar light acting upon the manganese. In 1839 Splittgerber recorded the following interesting fact in Poggendorf's *Annalen*, published in

Berlin: "I would mention a curious fact, in which the sunbeams have, if I may say so, done something in the art of penmanship—not only on the surface, but by inscribing characters through the body of the glass; and though the matter is based upon causes well known by experience, yet there has probably never before been so striking an instance of their effect known. I am in possession of a plate of glass which was used as a window-pane for more than twenty years, and on which was an inscription in gold letters. This inscription was taken off by grinding the plate on both sides, and polishing it so as to have a new surface. When the glass had been polished, the inscription could again be clearly seen. The parts which had been under the letters remained white, while the remainder of the plate had assumed a violet tint, in consequence of the manganese it contained, a coloring which permeates the whole mass, as the grinding of the surface proved. The uncovered part of the plate, especially when laid upon a white background, shows the clearly-readable characters."

From the above, it will be seen that the power of the sun's rays to change the color of glass has been publicly announced for at least a half-century; but it does not appear that elaborate and systematic experiments upon this subject were instituted prior to those referred to in the opening sentence of this article. These were begun in 1863, by Mr. Thomas Gaffield, a window-glass merchant of Boston, who has made an enthusiastic study of many matters pertaining to glass, and whose collection of authorities on this and kindred subjects is probably not equaled by any private, and by very few public, collections in existence. These experiments now cover a period of eleven years, and embrace some eighty different kinds of glass, of English, French, German, Belgian, and American manufacture, including specimens of rough and polished plate, crown, and sheet window-glass; flint and crown optical glass; opal and ground glass; colored pot-metal (i. e., glass colored in the pot during the process of melting); flashed and stained glass of various colors; and glass-ware and glass in the rough metal. The experiments have been conducted with pieces of glass usually four by two inches, of which several hundred specimens have been exposed, showing the effect of sunlight in producing a change of color by exposure, from one day in summer to several years. The changes produced in the colorless glasses are from white to yellow, from greenish to yellowish green, from brownish yellow to purple, from greenish white to bluish white, and from bluish white to a darker blue.

Mr. Gaffield's plan of procedure has been to cut a number of pieces of the size mentioned above, from the same sheet of glass, the number depending upon the nature of the experiment to be made. Suppose that white plate-glass is to be tested by exposure from one to twelve months: fourteen pieces, precisely alike, are cut from the same plate; two are carefully put away in a neat box, from which the light is excluded, and twelve are exposed to the sunlight. At the end of each month one of the exposed pieces is withdrawn from the light, carefully marked with a diamond to show the length of time exposed, and placed in the small dark box. At the end of the year, therefore, the collection embraces fourteen pieces—two of the original color, and twelve showing the effects of exposure from one to twelve months. Other collections may be made to show the daily, weekly, and yearly progress of the sun's rays in changing the color of the glass.

Mr. Gaffield found that, in the time required to produce a change, different specimens of glass presented widely different qualities, the change being much more easily effected in some than in others. In some specimens a marked change of color was observed in a few days; others, after resisting the powerful influence of the solar rays for years, were finally overcome, and made to assume a new color. Several kinds, in which no perceptible change took place in three months, were very sensibly affected by an exposure of a year. But in almost all the change took place.

"It is very interesting," says Mr. Gaffield, "to witness any one of these series of specimens, showing, as in one of white plate, a gradual change, commencing in a day or a few days in summer, from greenish or bluish white, to a yellowish white, or light yellow, a deep and deeper yellow, until it becomes a dark yellow or gold color; and, in some Belgian sheet specimens, a gradual change, commencing in a few weeks in summer, from brownish yellow to deeper yellow, yellowish pink, pink, dark pink, purple, and deep purple."

One interesting experiment was carried on for one year with nine different kinds of glasses, representing plate, crown, and cylinder glass, the manufacture of both hemispheres, and almost every shade and color of what are known as colorless glasses. The results were as follows:

KIND OF GLASS.	Color before Exposure.	Color after Exposure.
French white plate...	Bluish white	Yellowish.
German crystal plate.	Light green.	Bluish tinge.
English plate.......	" "	Yellowish green.
English crown.......	" "	Light purple.
Belgian sheet........	Brownish yellow.	Deep "
English sheet........	Dark green.	Brownish green.
American crystal sheet	Light bluish white.	Purplish white.
" " "	Lighter " "	Light yellowish green.
" ordinary....	Bluish green.	No change.

These colors appear from an observation of the glass edgewise, when is seen a body of color two or four inches in depth, whereas the usual thickness of the glass varies from one-fourteenth to one-quarter of an inch, and shows its color easily only when a white curtain or paper is placed behind it.

Among other experiments made by Mr. Gaffield, two may be noticed as of peculiar interest, and as suggesting a process of producing very delicate designs and pictorial effects on glass. In the first, an inscription was made on a piece of Belgian sheet-glass, in part with gold and silver leaf, and in part with black and white paint. The gold and silver leaf were washed off, but the letters painted in black and white remained. After an exposure of nearly two years the surface of the glass was cleaned, when the clearly-marked words of the inscription appeared in the original color of the glass, while the surrounding portions were changed by the action of the sunlight to a purple color. By the second experiment the gradually-increasing effect of sunlight on glass may be shown by exposing to the solar rays a piece of easily-changed glass. Take a piece about twenty inches long by four wide, and at each end cover a strip about four by two inches with black paint. At the end of one month, two months, and at biennial periods thereafter, paint an additional similar strip in black, until the entire piece is painted. Then, upon removing the paint, there will appear a single piece of glass presenting the original color, and all the gradations of color and hue presented by exposure from one to thirty-six months.

In 1825 Faraday thought that only glass containing oxide of manganese was subject to this change of color. In 1867 M. Pelouze did not "believe that there exists in commerce a single species of glass that does not change its shade in the sunlight." The results of Mr. Gaffield's experiments have led him to "affirm that a longer or shorter exposure to the direct action of the sun's rays will probably change in some degree the color of all or nearly all kinds of window-glass," and that the phenomenon is not limited to glass containing oxide of manganese. It should be observed that Mr. Gaffield's statement is limited to the ordinary window-glass, although embracing many different kinds of that class.

Specimens of flint and of colored glass have also been subjected to the test, but, with one or two exceptions, without exhibiting a change of color. An experiment, continued for five years, with red, yellow, green, blue, and purple pot-metal, i. e., glass colored in the pot, produced no change in any case except the purple. Still, this does not prove that changes may not be effected by longer exposure. Subsequently, Mr. Gaffield experimented with pot-metals, not of the primary colors, but of the intermediate ones, which most nearly approach those produced in colorless glass by sunlight exposure. In every specimen of the brownish, yellowish, and rose or purple colors thus exposed, a change in color or shade was produced in a short time. A change was also observed in the colorless body of some of the specimens of flashed and stained glass.

As pot-metal colors of this class were used in the early-painted windows, it is pertinently asked whether these experiments may not throw some light upon the many interesting questions relating to the alleged superiority of the old cathedral-glass.

"The fact of coloration," says Mr. Gaffield, "or change of color or shade by sunlight being established, must we not transfer some of our praise for the old artists in glass to the wonderful pencil of the brightest luminary of the heavens, which, during the centuries, has noiselessly but unceasingly been at work, deepening and mellowing the colors of all the windows of the venerable cathedrals of the world? We do not see to-day the glass as it was when it came from the artist's studio or the glass-factory. The dust of ages has accumulated upon its surface, the corroding tooth of Time has eaten into it; but how often has the wonderful alchemy of the sunlight done more in penetrating beneath the surface, and changing the shade or color of the entire body of the glass!"

The cause of the interesting phenomena above stated has not yet been explained, although not a few theories have been advanced to account for it. The change in color has been variously attributed to the presence of oxide of iron, to arsenic, to sulphur, and to oxide of manganese, in the constituent materials of the glass. But the true solution remains yet to be given. That the effect is not due to heat, but solely to the actinic rays of the sun, is shown by the fact that no change of color is produced in the glass when exposed to heat; while, on the contrary, after the discoloration has been produced by solar light, the colors thus acquired disappear under the action of heat, and the glass assumes its normal color. This process may be repeated indefinitely, the change of color being produced by solar light, and the original color restored by heat. It has also been shown that the effect is not produced by air or moisture.

Prominent among other interesting facts shown by these experiments is the varying effect of sunlight during each season, and each month of the year. The comparative actinic power of the rays during each month is shown, at the end of the year, by the comparative depth of yellow or purple color produced. The actinic effect increases from January to July, and decreases after the latter month; the greatest effect is observed in the summer, and the least in winter; in the spring and autumn it is about equal, being midway between that of winter and summer.

The comparative power of different kinds of glass to transmit the actinic rays was also tested. Of the colored glasses it was found that blue transmitted the most, purple less, and red and orange the least; which shows the propriety of the preference given by photographers to blue glass for skylights, because it transmits the blue rays, which exert the most active power. Mr. Gaffield's observations have not been confined to the glasses exposed on his own roof and window-sills; but he has been earnest in collecting, from various sources, specimens of window-glass that have been exposed for greatly-varying periods. By observing the portion of the pane exposed and that protected by the sash and putty, a comparison is afforded between the original and the acquired color of the glass. Among the gathered specimens was one of crown-glass, set in a church in Lexington, Mass., in 1794, from which the windows were removed in 1846, and afterward used as covers for hot-beds. The original color, ascertained by removing the putty from the edges, was a light green, and that produced by seventy-three years' exposure, a purple. Mr. Gaffield's efforts have also been directed toward examining the old cathedral-glass of Europe, where such observation is practicable. He still continues with great enthusiasm the experiments begun eleven years ago, and carefully records the results of his observations on a well-known phenomenon, "in the hopes that they may add some mite to the sum of human knowledge, and may stimulate and aid those who are better versed in scientific studies, to ascertain the causes and exact operations of this interesting power of the sun's rays to paint the products of art, as they do so beautifully and wonderfully the works of Nature on the mountain, in the forest and field."

MEASURES OF MENTAL CAPACITY.

By J. W. REDFIELD, M. D.

SCIENCE cannot look otherwise than favorably upon every attempt to determine the quantitative relations of mind and body; and much ingenuity has been expended in the effort to arrive at a geometrical expression of it. Aristotle, "the father of Natural History," as Prof. Agassiz calls him, speaks of an angle of the forehead to an horizontal line of the face as an indication of intelligence, and it is evident that the Greek sculptors designedly represented the superhuman attributes of the gods by an angle exceeding that of the highest human. It is not strange, therefore, that, when Camper restored the lost science and art of the measurement of psychological development, under the name of the Facial Angle, in 1784, the scientific world gave it a cordial welcome. But of course it could not be accepted as veritable scientific truth without running the gantlet of the severest criticism. Its most vulnerable point was a claim to be something more than a mere general rule, applicable to the designation of the rank of a species or of a race in the scale of intellectual and moral elevation. It claimed to be applicable to the distinction between nationalities, and even between individuals of the same class of society, both as to facial and as to mental characteristics. This was too much, and on this ground Blumenbach and others attempted to demolish it as a rule altogether, and by very many were supposed to have succeeded. Like other favorites, it had the misfortune to be made too much of, the consequence being that it came to be treated as of little worth. And yet nearly all comparative anatomists and physiologists make use of it as a general measure of the position of a vertebrate species in the scale of cerebral and mental development. As a mere "general rule," to which, as is familiarly said, "there are always exceptions," it is certainly invulnerable, and is too valuable to be dispensed with. Hence, naturalists, while declaring it to be unreliable, have made a general application of it to the species of vertebrates, and to the races of mankind. Not only so—they have attempted to find out the definite grains of allowance in its application to particular cases, to discover the corresponding defects in the instrument, and to correct, improve, and perfect it. May it not be that the mistake is not so much in the facial angle as in the misunderstanding of its significance? If this can be shown, naturalists and ethnologists ought to make haste to receive the much-honored and much-abused facial angle into more hearty favor than ever.

But it will hardly do to proceed to this pleasant task before stopping to notice the proposition of the article entitled "The Facial Angle," in the March number of THE POPULAR SCIENCE MONTHLY, to replace Camper's facial angle by another and better. The writer repudiates the angle of the frontal line with the base-line of the face, and proposes to supersede it by an angle of the frontal line with the axis of the body. He says, what everybody will admit, that the frontal line of the face is on a line with the axis of the body or spinal column, in the lowest vertebrates, and that the two lines are parallel with each other in man. The absurdity of finding a facial angle, or any other angle, between two parallel lines, is evident at a glance. It might take two or three glances, but no more, to convince the ordinary mind that those two lines, with the cerebrum and cerebellum between them, cannot come in contact with each other, and can therefore form no angle between them, even in the lower animals. Disregarding the interposition of the brain, and extending the front line of the face and the axial line of the body, in imagination, until they meet, the intersected angle is not facial, and in the anthropoids it is so high in the air overhead as to be essentially visionary. Perhaps this is the reason why we have to look in vain at the only facial angles represented in the article referred to, Figs. 2 and 3, to find an illustration of the new facial angle proposed, concluding finally that they were intended to illustrate the old one. The truth is, supposing the brain to unite, instead of separate, the frontal line of the face and the axial line of the body, the bending of the continuous right line formed by them in the lowest vertebrate fishes into the two parallel lines in man, the one facio-abdominal and the other occipito-dorsal, is not by angles at all, but by curvatures, and the union of the parallels is by an arch over the head. The arc in each case is a greater or less part of a circle, according to the grade of intellectual and moral development. For example: In the typical man, the facial and dorsal lines, being parallel and perpendicular, are united at the top by a semicircle, very nearly describing "the dome of thought, the temple of the soul." In the gorilla, the same lines, being inclined to each other, are united by about a quarter of a circle, nearly circumscribing the cranial and mental capacity of that venerable progenitor of ours. In the goat, the same lines, being still more inclined, are united by about an eighth of a circle, giving verge and room enough for his caprices. And so on to the least part of a circle, representing the least cerebral and mental capacity.

The rule of comparison here indicated will apply perfectly to each one of the ten profiles illustrating the scale of development in the principal figure of the article in question; but that artificial angle of the frontal line of the face to the dorsal line of the body will not apply at all to intelligent human beings, except in the case of the Flatheads, whose peculiar conformation has been produced by a too rigid application of it in their plastic infancy. In man as Nature made him, the front line of the facial angle can form an angular relation to the axis of the body *through the base-line* of the facial angle, and in no other way. At the top of the head the front and dorsal lines can only meet in a curve, and there they form what may more properly be called the cranial arch than the facial angle. The facial angle of Camper is truly an angle and truly facial, but the proposed substitute for it is neither. Nature really does form angles of varying acuteness and obtuseness to the base-line of the face at its two extremities—very acute angles between it and the front line of the face at its anterior extremity, and very obtuse angles between it and the line of the spinal column at its posterior extremity, in the lower vertebrates, and almost right angles at the same points in human beings. Those formed by the front and base lines of the face constitute the facial angle of the upper part of the face, and indicate the degrees of intellectual and artistic development: those formed by the base-line of the face and the axial line of the neck constitute the facial angle of the lower part of the face, and indicate the degrees of affectional and passional development.

To do full justice to the article we have stopped to consider, we must not slight the assertion on which the author bases his objection to Camper's facial angle and his preference for his own, namely, that "the base of the skull does not keep in harmony" with the front of the face in the changes that occur through the stages of vertebrate evolution, but that it "varies irregularly," while the "axis of the body" does not. A little examination will show this to be a great mistake. While the lines representing the front face and dorsal surfaces are "effecting a grand variation of 180°, or the half of a circle"—beginning with the lowest vertebrate, in which those lines are "in direct line" with each other, and ending with the highest vertebrate, in which they are parallel with each other—the line representing the base of the face, extending along the floor of the nostril to the occipital condyle, remains stationary. While the upper jaw maintains its fixed position, the lower jaw plays upon it; and so, while the base-line of the face in the upper jaw remains steadfast, the lines based and dependent upon it—the front facial line above, and the axial line below—are each effecting variations of 90° in relation to it, the one in relation to its anterior extremity and upper surface, and the other in relation to its posterior extremity and under surface, passing on the way through the angles represented in *a b*, Fig. 1, and ending as represented in *a b*, Fig. 2—the two variations together con-

Fig. 1.

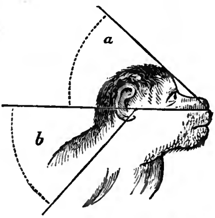
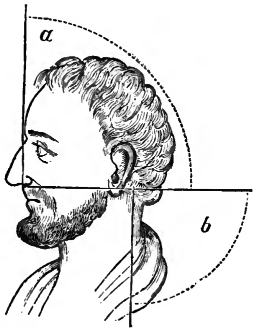


Fig. 2.



Degrees of the Superior and Inferior Facial Angles.

stituting the variation of 180°, or the half-orbit before mentioned. The base-line of the skull, so far from "varying irregularly," varies not at all, but is always straight, and in the most natural position of the head is always horizontal, while the frontal line of the face and the dorsal line of the body diverge more and more from the horizontal, and become more and more irregular in figure. The position of the head natural to social intercourse and to an outlook upon the horizon, as the general rule, is the one thing in which not only all men, but all vertebrate animals, are agreed, but they take infinite liberty to disagree in all other things, for the sake of showing the infinite diversity of individualities necessary to their harmonious interrelations and to the perfect individuality of the whole. When a man's "head is level," he is on a plane of equality, as a man and an animal, not only with his fellow-men, but with his fellow-creatures, and in a position to harmonize his differences with theirs. This horizontal position of the base-line of the face makes it the standard by which to compare the other lines, and by which to estimate the degrees of intelligence and affection as indicated by the degrees of the angles they make with it. When we consider how irregular in position and contour the spine and the features of the face become in the course of transition from the lowest vertebrate forms to the highest, we see the absurdity of making either of these lines the basis of an angle in relation to the other. Take the novel rule, that for the true facial angle "the relation of the [front] face is not to the base of the skull, but to the axis of the body," and, for example, apply it to the camel! What sort of work would we make in deciphering such a hieroglyphical facial angle as that? But, considering the invariable straightness of the base of the skull, and its horizontal position in the attitude of attention, or in the social exercise of the external and internal senses and emotions, and considering at the same time the infinite variety of forms and motions given by these faculties to the features and muscles of the face and to the spinal column and its appendages, we see the propriety of making the base-line the standard of comparison for the two other lines in the construction of our facial angles and in our method of using them. All things considered, we may plant ourselves anew on the base-line of the old facial angle, assured that it is what its name signifies—fundamental, the centre of support and dependence between the transitional and variable lines, and presenting fixed extremities, constituting axial centres, in relation to which the movable lines are radii, forming with the base-line angles of all degrees between one and ninety in the development of animal life, from the lowest vertebrate form up to its highest and most perfect type. No one can read Camper's work "On the Connection between the Science of Anatomy and the Arts of Drawing, Painting, and Statuary," and examine its numerous and scrupulously accurate illustrations, without being convinced that the facial angle there described is founded in Nature, in spite of all the criticisms he or others may be able to pass upon it. If it be true, as Herbert Spencer says, that science is distinguished from common knowledge by being a more accurate system of measurements of ordinary phenomena, guided by more accurately understood and applied principles of generalization, Camper's facial angle may be regarded as the first step of a strictly scientific mind in the erection of a positive science of Comparative Physico-Psychology; and we have only to learn its true significance better than the master, by following the same induction of generals in regard to each particular line of it that he followed in regard to the whole, in order to complete the magnificent superstructure for which he laid so solid a foundation.

LAW AND INSANITY.[1]

By HENRY MAUDSLEY, M.D.

LOOKING back at the strange and erroneous notions which were formerly entertained of the nature and causes of insanity, and considering what little observation was made of its manifold varieties, we cannot wonder that its jurisprudence was in a very defective state. At first two kinds of insanity only seem to have been recognized by English law—*idiocy* and *lunacy:* the idiot who, from his nativity, by a perpetual infirmity is *non compos*, and the lunatic, who hath sometimes his understanding, and sometimes not, *aliquando gaudet lucidis intervallis*, and therefore is *non compos mentis*, so long as he hath not understanding. But as time went on a partial insanity was recognized as distinct from total insanity, although this partial insanity was declared not to absolve a person from responsibility for his criminal acts. "There is," says Lord Hale, "a partial insanity, and a total insanity. The former is either in respect to things, *quoad hoc vel illud insanire.* Some persons that have a competent use of reason in respect of some subjects, are yet under a particular *dementia* in respect of some particular discourses, subjects, or applications; or else it is partial in respect of degrees; and this is the condition of very many, especially melancholy persons, who for the most part discover their defect in excessive fears and griefs, and yet are not wholly destitute of the use of reason; and this partial insanity seems not to excuse them in the committing of any offense for its matter capital; for, doubtless, most persons that are felons of themselves and others are under a degree of partial insanity when they commit these offenses. It is very difficult to define the invisible line that divides perfect and partial insanity; but it must rest upon circumstances duly to be weighed by judge and jury, lest, on the one side, there be a kind of inhumanity toward the defects of human nature; or, on the other side, too great an indulgence given to great crimes." The invisible line which it was so difficult to define was not, let it be noted, between sanity and insanity, but between perfect and partial insanity. It was thought no inhumanity toward the defects of human nature to punish as a fully responsible agent a person who was suffering from partial insanity, whatever influence the disease might have had upon his unlawful act.

The principle thus laid down by Lord Hale was subsequently acted upon in English courts. Thus, in the trial of Arnold, an undoubted lunatic, for shooting at Lord Onslow, in 1723, Mr. Justice Tracy said: "It is not every kind of frantic humor, or something unaccountable in a man's actions, that points him out to be such a madman as is ex-

[1] From advance sheets of "Responsibility in Mental Disease," No. 9 of the "International Scientific Series."

empted from punishment: it must be a man that is totally deprived of his understanding and memory, and doth not know what he is doing, no more than an infant, than a brute or a wild beast; such a one is never the object of punishment." In this respect a wide distinction was maintained between civil and criminal cases; for while the law would not allow exemption from punishment for criminal acts unless the reason was entirely gone, it invalidated a person's civil acts, and deprived him of the management of himself and his affairs, when his insanity was only partial, and when the act voided had no discoverable relation to it. A man's intellect might not be sufficient to enable him to conduct his affairs, and to dispose of his property, though quite sufficient to make him responsible for a criminal act: it was right to hang for murder one who was not thought fit to take care of himself and his affairs.

It was at the trial of Hadfield, in 1800, for shooting at the king in Drury Lane Theatre, that Lord Hale's doctrine was first discredited, and a step forward made for the time. The attorney-general, who prosecuted, had appealed to this doctrine, and told the jury, in accordance with it, that, to exempt a person from punishment on the ground of insanity, there must be a total deprivation of memory and understanding. Mr. Erskine, who was counsel for the defense, argued forcibly in reply, that if such words were taken in their literal sense, "no such madness ever existed in the world;" that in all the cases that had filled Westminster Hall with complicated considerations, "the insane persons had not only had the most perfect knowledge and recollection of all the relations they stood in toward others, and of the acts and circumstances of their lives, but had in general been remarkable for subtlety and acuteness; and that delusion, of which the criminal act in question was the immediate unqualified offspring, was the kind of insanity which should rightly exempt from punishment. Delusion, therefore, where there is no frenzy or raving madness, is the true character of insanity." There was no doubt that Hadfield knew right from wrong, and that he was conscious of the nature of the act before he committed it; he manifested design in planning and cunning in executing it; he expected also that it would subject him to punishment, for this was his motive in committing it; still it was plain to everybody that he was mad, and that the act was the product of his madness. The result was that he was acquitted, the acquittal not having taken place in consequence of a judicial adoption of delusion in place of the old criterion of responsibility, as it has sometimes been said, but having been rather a triumph of Erskine's eloquence, and of common-sense over legal dogma.

In the next remarkable case, that of Bellingham, who was tried for the murder of Mr. Spencer Perceval, in 1812, a conviction took place, and the prisoner was executed, although it was perfectly clear that he had acted under the influence of insane delusions; the attorney-general, who prosecuted, declaring, and Chief-Justice Mansfield, who tried the case, concurring, "upon the authority of the first sages in the country, and upon the authority of the established law in all times, which has never been questioned, that although a man might be incapable of conducting his own affairs, he may still be answerable for his criminal acts, if he possess a mind capable of distinguishing right from wrong." Note here, then, that a modification had now been made in the test of responsibility; in place of its being required that the sufferer, in order to be exempt from punishment, should be totally deprived of understanding and memory, and know not what he was doing, no more than a brute or a wild beast—in place, that is, of what might be called the "wild-beast" form of the knowledge-test, the power of distinguishing right from wrong was insisted on as the test of responsibility. The law had changed considerably without ever acknowledging that it had changed. Let it be observed, however, that it was the power of distinguishing right from wrong, not in relation to the particular act, but generally, which was made the criterion of responsibility in this case; for Lord Mansfield, speaking of the kind of insanity in which the patient has the delusion of being injured, and revenges himself by some hostile act, said that, "if such a person were capable, *in other respects*, of distinguishing right from wrong, there was no excuse for any act of atrocity which he might commit under this description of derangement. It must be proved beyond all doubt that, at the time he committed the atrocious act, he did not consider that murder was a crime against the laws of God and Nature." [1]

Thus far it is evident that principle was changing and practice was uncertain. After the old "wild-beast" form of the knowledge-test had been quietly abandoned, when the enunciation of it caused too violent a shock to the moral sense of mankind, we find two theories acted upon in practice: in the case of Hadfield the existence of delusion instigating the criminal act was the reason of his acquittal; in

[1] Dr. Ray thus comments upon this doctrine: "That the insane mind is not entirely deprived of this power of moral discernment, but on many subjects is perfectly rational and displays the exercise of a sound and well-balanced mind, is one of those facts now so well established, that to question it would only display the height of ignorance and presumption. The first result, therefore, to which the doctrine leads is, that no man can successfully plead insanity in defense of crime; because it can be said of no one who would have occasion for such a defense, that he was unable in any case to distinguish right from wrong. . . . The purest minds cannot express greater horror and loathing of various crimes than madmen often do, and from precisely the same causes. Their abstract conceptions of crime, not being perverted by the influence of disease, present its hideous outlines as they ever were in the healthiest condition; and the disapprobation they express at the sight arises from sincere and honest convictions. The *particular* criminal act, however, becomes divorced in their minds from its relations to crime in the *abstract;* and, being regarded only in connection with some favorite object which it may help to obtain, and which they see no reason to refrain from pursuing, is viewed, in fact, as of a highly-laudable and meritorious nature. Herein, then, consists their insanity—not in preferring vice to virtue, in applauding crime and deriding justice, but in being

Bellingham's case, an absence of knowledge of right and wrong generally, not in respect of the particular act, was deemed necessary to exempt the individual from punishment; the latter theory being entirely inconsistent with the former, and neither of them being consistently acted upon in subsequent trials. Most often a knowledge of right and wrong, without reference to the particular act, was plainly declared by the judge to be the simple and sufficient criterion of responsibility, and the jury was instructed accordingly; but this criterion was sometimes modified by the qualifications which judges introduced to meet their individual views, or to prevent the conviction of a person who was plainly insane and irresponsible. There was no settled principle, no actual uniformity of practice, no certainty of result.

In this uncertain way matters went on until a great sensation was made by the murder, in 1843, of Mr. Drummond by McNaughten, who shot him under the influence of a delusion that he was one of a number of persons whom he believed to be following him everywhere, blasting his character and making his life wretched. McNaughten had transacted business a short time before the deed, and had shown no obvious symptoms of insanity in his ordinary discourse and conduct. He was, however, acquitted on the ground of insanity. Thereupon the House of Lords, participating in the public alarm and indignation which were occasioned by the acquittal, propounded to the judges certain questions with regard to the law on the subject of insanity when it was alleged as a defense in criminal actions; the object being to obtain from them an authoritative exposition of the law for the future guidance of courts. The answers of the judges to the questions thus put to them constitute the law of England as it has been applied since to the defense of insanity in criminal trials.

It is not necessary to quote the questions and answers at length; the latter are somewhat confused, and the substance of them may be correctly given in fewer words. "To establish a defense on the ground of insanity, it must be clearly proved that at the time of committing the act the party accused was laboring under such a defect of reason from disease of the mind as not to know the nature and quality of the act he was doing, or, if he did know it, that he did not know he was doing what was wrong." It will not escape attention that the question of right and wrong in the abstract was here abandoned, being allowed quietly to go the way of the wild-beast form of the knowledge-test; the question of right and wrong was to be put in reference *to the par-*

unable to discern the essential identity of nature between a particular crime and all other crimes, whereby they are led to approve what, in general terms, they have already condemned. It is a fact, not calculated to increase our faith in the 'march of intellect,' that the very trait peculiarly characteristic of insanity has been seized upon as a conclusive proof of sanity in doubtful cases; and thus the infirmity that entitles one to protection, is tortured into a good and sufficient reason for completing his ruin."—("A Treatise on the Medical Jurisprudence of Insanity," fifth edition, pp. 26–28.)

ticular act with which the accused was charged. Moreover, it was to be put in reference to the particular act *at the time of committing it.* Did he at the time know the nature and quality of the act he was doing? These two points have been overlooked sometimes by hostile critics, who have condemned the rule enunciated, as though it referred to a knowledge of right and wrong generally. One may object to the rule as a bad one, and because it is calculated to mislead a jury, who are very likely to be misled by the existence of a general knowledge of right and wrong in the accused person to judge wrongly concerning his knowledge of the particular act at the time, but it must be allowed at the same time that it will, if strictly applied, cover and excuse many acts of insane violence. Of few insane persons who do violence can it be truly said that they have a full knowledge of the nature and quality of their acts at the time they are doing them. Can it be truly said of any person who acts under the influence of great passion that he has such a knowledge at the time?

The rule thus laid down, differing so much from that which was enunciated and mercilessly acted upon in Bellingham's sad case, was, however, limited in its application by a formidable exception. In reply to the question—"If a person, under an insane delusion as to existing facts, commits an offense in consequence thereof, is he thereby excused?"—the judges declared that "on the assumption that he labors under partial delusion only (whatever that may mean), and is not in other respects insane, he must be considered in the same situation as to responsibility as if the facts with respect to which the delusion exists were real. For example, if, under the influence of delusion, he supposes another man to be in the act of attempting to take his life, and he kills that man, as he supposes, in self-defense, he would be exempt from punishment. If his delusion was that the deceased had inflicted a serious injury to his character and fortune, and he killed him in revenge for such supposed injury, he would be liable to punishment." Here is an unhesitating assumption that a man, having an insane delusion, has the power to think and act in regard to it *reasonably;* that, at the time of the offense, he ought to have and to exercise the knowledge and self-control which a sane man would have and exercise, were the facts with respect to which the delusion exists real; that he is, in fact, bound to be reasonable in his unreason, sane in his insanity. The judges thus actually bar the application of the right-and-wrong criterion of responsibility to a particular case, by authoritatively prejudging it; instead of leaving the question to the jury, they determine it beforehand by assuming the possession of the requisite knowledge by the accused person. One of them, however, Mr. Justice Maule, so far dissented as to maintain that the general test of capacity to know right from wrong in the abstract ought to be applied to this case as to other cases.

But this is not all the uncertainty which appears in these answers.

In another part of them it is said, in reference to the same supposed case, that "notwithstanding the party accused did the act complained of with a view, under the influence of insane delusion, of redressing or revenging some supposed grievance or injury, or of producing some public benefit, he is nevertheless punishable, if he knew at the time of committing such crime that he was acting contrary to the law, by which is meant the law of the land." This answer really conflicts with a former answer; it is obvious that the knowledge of right and wrong is different from the knowledge of an act being contrary to the law of the land; and it is certain that an insane person may do an act which he knows to be contrary to law, because, by reason of his insanity, he believes it to be right, because, under the influence of insane delusion, he is a law unto himself, and deems it a duty to do it, perhaps "with a view of producing some public benefit."

The uprightness of English judges has happily been seldom called in question, but it may well be doubted whether the result of their solemn deliberations, as embodied in their answers to the questions put to them by the House of Lords, will commend their wisdom to the approbation of foreign nations and future ages. If it be true, as is sometimes said, that the verdict of foreign nations is an anticipation of the verdict of posterity, there are already sufficiently strong indications that their conclusions will be no honor to them in times to come. That they are unanimously condemned by all physicians who have a practical knowledge of the insane, may not affect the confidence of those who accept them, seeing that judges and physicians take such different stand-points; but when the judges of other countries condemn them with equal earnestness, it is impossible for the most confident to help feeling some hesitation. In the case of *State* v. *Jones*, tried in the court of New Hampshire, America, Judge Ladd, after passing in review the answers of the English judges, thus speaks of the doctrine embodied in them:

"The doctrine thus promulgated as law has found its way into the text-books, and has doubtless been largely received as the enunciation of a sound legal principle since that day. Yet it is probable that no ingenious student of the law ever read it for the first time without being shocked by its exquisite inhumanity. It practically holds a man, confessed to be insane, accountable for the exercise of the same reason, judgment, and controlling mental power, that are required in perfect mental health. It is, in effect, saying to the jury, the prisoner was mad when he committed the act, but he did not use sufficient reason in his madness. He killed a man because, under an insane delusion, he falsely believed the man had done him a great wrong, which was giving rein to a motive of revenge, and the act is murder. If he had killed a man only because, under an insane delusion, he falsely believed the man would kill him if he did not do so, that would have been giving the rein to an instinct of self-preservation, and would not be crime. It is true in words the judges attempt to guard against a consequence so shocking as that a man may be punished for an act which is purely the offspring and product of insanity, by introducing the qualifying phrase, 'and is not in other respects insane.' That is, if insanity produces the false belief, which is the prime cause of the act, but goes no further, then the accused is to be judged according to the character of motives which are presumed to spring up out of that part of the mind which has not been reached or affected by the delusion or the disease. This is very refined. It *may be* that mental disease sometimes takes a shape to meet the provisions of this ingenious formula; or, if no such case has ever yet existed, it is doubtless within the scope of Omnipotent power hereafter to strike with disease some human mind in such peculiar manner that the conditions will be fulfilled; and, when that is done, when it is certainly known that such a case has arisen, the rule may be applied without punishing a man for disease. That is, when we can certainly know that although the false belief on which the prisoner acted was the product of mental disease, still that the mind was in no other way impaired or affected, and that the *motive* to the act did certainly take its rise in some portion of the mind that was yet in perfect health, the rule may be applied without any apparent wrong. But it is a rule which can safely be applied in practice that we are seeking; and to say that an act which grows wholly out of an insane belief that some great wrong has been inflicted, is at the same time produced by a spirit of revenge springing from some portion or corner of the mind that has not been reached by the disease, is laying down a pathological and psychological fact which no human intelligence can ever know to be true, and which, if it were true, would not be *law*, but pure matter of fact. No such distinction ever can or ever will be drawn into practice; and the absurdity as well as the inhumanity of the rule seems to me sufficiently apparent without further comment. . . . It is a question of fact whether any universal test exists, and it is also a question of fact what that test is, if any there be."[1]

Since the answers of the judges were made to the House of Lords, the law as relating to insanity in a criminal trial has been laid down in conformity with their conclusions: if the accused person at the time of committing the offense knew right from wrong, and that he was doing wrong, he must be brought in guilty, whether insane or not. If insane, he is not necessarily exempted from the punishment of his crime; the question is, whether he was at the time capable of committing a crime; and that must be determined by evidence of the absence, not of insanity, but of a knowledge of right and wrong. Was his insanity of such a kind as to render him irresponsible by destroying his knowledge of right and wrong? Nevertheless, juries often, and judges occasionally, out of a natural humanity repudiate this dogma in particular cases, and, so far from any certainty of result having been secured by its application, it is notorious that the acquittal or conviction of a prisoner, when insanity is alleged, is a matter of chance. Were the issue to be decided by tossing up a shilling, instead of by the grave procedure of a trial in court, it could hardly be more uncertain. The less insane person sometimes escapes, while the more insane person is sometimes hanged; one man laboring under a particular form of derangement is acquitted at one trial, while another having an exactly similar form of derangement is convicted at another trial. No

[1] *State* v. *Jones*, p. 388.

one will be found to uphold this state of things as satisfactory, although there is great difference of opinion as to the cause of the uncertainty; the lawyers asserting that it is owing to the fanciful theories of medical men who never fail to find insanity where they earnestly look for it, the latter protesting that it is owing to the unjust and absurd criterion of responsibility which is sanctioned by the law. Meanwhile, it is plain that, under the present system, the judge does actually withdraw from the consideration of the jury some of the essential facts, by laying down authoritatively a rule of law which prejudges them; the medical men testify to facts of their observation in a matter in which they alone have adequate opportunities of observation; the judge, instead of submitting these facts to the jury for them to come to a verdict upon, repudiates them by the authority of a so-called rule of law, which is not rightly law, but is really false inference founded on insufficient observation.

In America it would seem that matters have been little better than they are in this country, the practice of the courts, like that of the British courts, having been diverse and fluctuating. In many instances juries have been instructed, in accordance with English legal authorities, that, if the prisoner, at the time of committing the act, knew the nature and quality of it, and that in doing it he was doing wrong, he must be held responsible, notwithstanding that on some subjects he may have been insane; that, in order to exempt a person from punishment, insanity must be so great in extent or degree as to destroy his capacity of distinguishing between right and wrong in regard to the particular act. But in other instances the instructions of the judges have been different. In the case of *State* v. *Wier*, Grafton, 60, 1864, Chief-Justice Bell charged the jury thus:

"The evidence must satisfy the jury that the party at the time of committing the act in question was insane, and that the disease is of such severity that the person is incapable of distinguishing between right and wrong in that particular case, or of controlling the sudden impulse of his own disordered mind; or, as the same rule has been laid down by an eminent judge, a person, in order to be punishable by law, must have sufficient memory, intelligence, reason, and will, to enable him to distinguish between right and wrong in regard to the particular act about to be done, to know and understand that it will be wrong, and that he will deserve punishment by committing it; to *which* I add *sufficient mental power to control the sudden impulses of his own disordered mind*. . . . I have been accustomed to regard as the *distinguishing test* of insanity *the inability to control the actions of a man's mind*. . . . The power of the control of the thoughts being lost, the power of the will over the conduct may be equally lost, and the party under the influence of disease acts not as a rational being, but under the blind influence of evil thoughts which he can neither regulate nor control. It was, perhaps, not without reason that in ancient times the insane were spoken of as possessed of an evil spirit, or possessed with a devil, so foreign are the impulses of that evil spirit to all the natural promptings of the sane heart and mind."[1]

[1] Quoted in the Report of *State* v. *Jones*, pp. 376, 377.

In the case of *Stevens* v. *The State of Indiana*, the instruction to the jury, that, if they believed the defendant knew the difference between right and wrong in respect to the act in question, if he was conscious that such act was one which he ought not to do, he was responsible—was held to be erroneous.

It would appear, then, that the American courts, which, having inherited the common law of England, at first followed docilely in the wake of the English courts, are now exhibiting a disposition to emancipate themselves from an authority which they perceive to be founded on defective and erroneous views of insanity, and a desire to bring the law more into accordance with the results of scientific observation. The decisions of the court of New Hampshire in *Boardman* v. *Woodman*, *State* v. *Jones*, and *State* v. *Pike*, are especially worthy of attention for their searching discussion of the relations of insanity to jurisprudence, and for the decisive abandonment of the right-and-wrong test of responsibility. In the case of *State* v. *Pike*, Chief-Justice Perley instructed the jury that they should return a verdict of not guilty "if the killing was the offspring of mental disease in the defendant; that neither delusion nor knowledge of right and wrong, nor design or cunning in planning and executing the killing, and in escaping or avoiding detection, nor ability to recognize acquaintance, or to labor or transact business or manage affairs, is, as a matter of law, a test of mental disease; but that all symptoms and all tests of mental disease are purely matters of fact to be determined by the jury."

"A striking and conspicuous want of success," said Judge Doe in the same case, "has attended the efforts made to adjust the legal relations of mental disease. . . . It was for a long time supposed that men, however insane, if they knew an act to be wrong, could refrain from doing it. But whether that suspicion is correct or not is a pure question of fact; in other words, a medical supposition—in other words, a medical theory. Whether it originated in the medical or any other profession, or in the general notions of mankind, is immaterial. It is as medical in its nature as the opposite theory. The knowledge-test in all its forms, and the delusion-test, are medical theories introduced in immature stages of science, in the dim light of earlier times, and subsequently, upon more extensive observations and more critical examinations, repudiated by the medical profession. But legal tribunals have claimed these tests as immutable principles of law, and have fancied they were abundantly vindicated by a sweeping denunciation of medical theories—unconscious that this aggressive defense was an irresistible assault on their own position. . . . In this manner, opinions, purely medical and pathological in their character, relating entirely to questions of fact, and full of errors, as medical experts now testify, passed into books of law, and acquired the force of judicial decisions. Defective medical theories usurped the position of common-law principles. . . . Whether the old or the new medical theories are correct is a question of fact for the jury; it is not the business of the court to know whether any of them are correct. The law does not change with every advance of science; nor does it maintain a fantastic consistency by adhering to medical mistakes which science has corrected. The legal principle, however much it may formerly have been obscured by pathological darkness and confusion, is that a product of mental disease is not a contract, a will, or a crime. It is often difficult to ascertain whether an individual has a mental disease, and whether an act was the product of that disease; but these difficulties arise from the nature of the facts to be investigated, and not from the law; they are practical difficulties to be solved by the jury, and not legal difficulties for the court."

These American decisions are certainly an advance on any judgment concerning insanity which has been given in this country; they put in a proper light the relations of medical observation and law in questions of mental disease; and it cannot be doubted that future progress will be along the path which they have marked out. The question which will probably be submitted to the jury will be substantially, Was the act the offspring or product of mental disease?—and it will be seen that to lay down any so-called test of responsibility, founded on a supposed knowledge of right and wrong, is, as Judge Ladd remarked in *State* v. *Jones*, "an interference with the province of the jury, and the enunciation of a proposition which, in its essence, is not law, and which could not in any view safely be given to the jury as a rule for their guidance, because, for aught we can know, it may be false in fact." Seeing, then, that, by the unanimous testimony of medical men of all countries who have been practically acquainted with insanity, it is declared positively that such a proposition is false in fact, it is clear that the law, in enunciating it, is not only overstepping its rightful function, but actually perpetrating an injustice. It is simply doing in regard to insanity what it did formerly in regard to witchcraft—giving erroneous opinions on matters of fact to the jury under the name of law, and with all the weight of judicial authority. In one of the latest trials for witchcraft in this country, Lord Hale, whose crude dicta concerning insanity were so long acted upon in our courts of justice, instructed the jury: "That there are such creatures as witches he made no doubt at all. For, first, the Scriptures had affirmed so much. Secondly, the wisdom of all nations had provided laws against such persons, which is an argument of their confidence of such a crime." The jury accordingly found a verdict of guilty; the judge, satisfied with it, condemned the prisoners to death, and they were executed. It is one of the last executions for witchcraft in this country, for it occurred at a time—and this should never be forgotten—when the belief in witchcraft was condemned by the enlightened opinion of the country. As it was then with witchcraft, so it is now with insanity: the judge instructs the jury wrongly on matters of fact; they find accordingly a verdict of guilty; he is satisfied with the verdict, and an insane person is executed.

The falseness of the legal position will appear at once if we suppose a case of poisoning instead of a case of mental derangement: what would be thought of a judge who, when medical evidence of poisoning was given, should instruct the jury, as a principle of law, that they must be governed in their verdict by the presence or absence of a particular symptom? "If the tests of insanity are matters of law, the practice of allowing experts to testify what they are should be discontinued; if they are matters of fact, the judge should no longer testify without being sworn as a witness, and showing himself qualified to testify as an expert."[1] But, in truth, the tests of insanity are no more matters of law than are the tests of a poison or the symptoms of disease. "If a jury were instructed that certain manifestations were symptoms or tests of consumption, cholera, congestion, or poison, a verdict rendered in accordance with such instructions would be set aside, not because they were not correct, but because the question of their correctness was one of fact to be determined by the jury upon evidence."[2]

Other nations have not bound themselves by so narrow and ill-founded a criterion of responsibility in insanity; they have refrained from the attempt to define exactly the conditions of responsibility. In France the article of the penal code is: "There can be no crime nor offense if the accused was in a state of madness at the time of the act." And the revised statutes of the State of New York enact that "no act done by a person in a state of insanity can be punished as an offense." These general enactments, while wisely leaving each case to be decided on its merits, may clearly be construed, if they were not intended, to exempt from punishment the individual who, being partially insane, nevertheless commits a crime which is no way connected with his insanity; who, in fact, so far as can be judged, does it in the same way and from exactly the same motive as a sane person. For an insane person is not exempt from the ordinary evil passions of human nature; he may do an act out of jealousy, avarice, or revenge: is it right, then, when, so far as appears, the passion is not connected with his diseased ideas or feelings, and he acts with criminal intent, that he should escape punishment for what he has done? This is really the important question which must continue to puzzle courts of justice when a particular criterion of responsibility is no longer laid down; for if it be admitted that an insane person who apparently does a criminal act sanely ought not to escape punishment, the difficulty of deciding whether his disease did or did not affect the act will remain. There will always be room enough for doubts and differences of opinion.

The section of the latest German penal code is: "An act is not punishable when the person at the time of doing it was in a state of unconsciousness or of disease of mind, by which a free determination of the will was excluded." Not every disorder of mind is exempt; only such actual disease as excludes a free determination of the will. The problem, then, is, to determine, first, what conditions of derangement of the mental faculties are to be considered as the result of dis-

[1] Judge Doe, *State* v. *Pike*. [2] *Boardman* v. *Woodman*.

ease; and, secondly, whether and how far free-will is excluded by them. In the case of a partially insane person acting to all appearances from an ordinary criminal motive, the act must be weighed in relation to these two questions; and, if they are answered in the negative, he would clearly be amenable to punishment.

It is abundantly evident from this short review of the codes of other countries that nothing can be said in justification of the superstitious reverence with which English lawyers cling to their criterion of responsibility. It is hard to see why they should suffer a greater pang in giving up this formula than they did in giving up other formulas which, having had their day and done much evil work, were abandoned. The "wild-beast theory," once so sacred, has been relegated to the record of human mistakes; the theory of a knowledge of right and wrong in the abstract which followed it was, in like manner, repudiated as men became better acquainted with the phenomena of mental derangement; surely, then, the metaphysical theory of a knowledge of right and wrong in relation to the particular offense, which finds little or no favor out of England, and which is condemned unanimously by all persons, in all countries, who have made insanity their study, may be suffered to join its predecessors, without danger of injury to what all those who approve and those who disapprove it desire — the strict administration of justice. Physicians have no right to interfere in the administration of the law, which is the judge's function, nor is it their duty to decide upon what is necessary to the welfare of the state, that being the legislator's work; their concern is with the individual, not with the citizen. But they plainly have the right to declare that the nature of a crime involves two elements: first, the knowledge of its being an act contrary to law; and, secondly, the will to do or to forbear doing it, and to point out that there are some insane persons who, having the former, are deprived by their disease of the latter; who may know an act to be unlawful but may be impelled to do it by a conviction or an impulse which they have not the will or the power to resist. Recognizing the obvious difference between him who *will* not and him who *cannot* fulfill the claims of the law, it is their function to point out the conditions of disease which constitute incapacity, and, when they find a false fact solemnly enunciated as a rule of law, to bring forward into all the prominence they can the contradictory instances which their observation makes known to them. "That cannot be a fact in law which is not a fact in science; that cannot be health in law which is disease in fact. And it is unfortunate that courts should maintain a contest with science and the laws of Nature upon a question of fact which is within the province of science and outside the domain of law." [1]

[1] Judge Doe, *Boardman* v. *Woodman*. "If it is necessary that the law should entertain a single medical opinion concerning a single disease, it is not necessary that that opinion should be a cast-off theory of physicians of a former generation."—(P. 150.)

OBSERVATIONS OF A NATURALIST IN NICARAGUA.

MR. CHARLES BELT has given us, in an interesting volume, the results of his natural history studies during a residence of four years in Nicaragua. His opportunities were excellent, and he has the faculty of turning them to good account. He found the climate of the region of almost uninterrupted summer, with abundant rainfall excepting in localities on the western slopes of mountains, and consequently a great profusion of animal and vegetable forms of life.

The eastern belt of the country is described as one unbroken forest, where perennial moisture reigns in the soil, perennial summer in the air, and vegetation luxuriates in ceaseless activity. Unknown are the autumn tints of English woods and the unrivaled splendors of the foliage of Canada. The trees do not grow in clusters, like our firs and oaks, but crowd upon each other in unsocial rivalry, struggling to keep their upper branches and leaves in the sunlight. A vast network of cable-like plants entangles the trees, and gorgeous air-plants dangle everywhere.

The central belt is of elevated grounds and grassy savannahs, but the Pacific slope is of rich, deep soil of decomposing tufas, where tropical fruits are abundant and prolific. It is an interesting fact that the mountains show everywhere traces of former glaciers. Enormous bowlders, beds of bowlder-clay and unstratified gravels, and rocks with smoothed rounded surfaces, suggest the former presence of ice.

In the profusion of animal life the struggle for existence is intense and incessant, and Mr. Belt was at once impressed with the extent to which protective coloring and other mimetic resemblances were found to exist. Thus wasps and stinging ants have hosts of imitators among moths, beetles, and bugs. A curious longicorn beetle was found covered with long brown and black hairs, closely resembling hairy caterpillars, common in the bushes, but which birds are known not to touch. The well-known phasma, or leaf-insect, escapes danger and eludes observation by its wonderful resemblance to leaves; and one species of this insect, in its larval stage, is called the moss-insect, and so closely resembles the moss it inhabits as not to be distinguished from it unless disturbed. The same is true of spiders which assume a resemblance to the petals of flowers in which they hide.

A curious green lizard was common in the wild-canes and grass, having leaf-like expansions, on account of which it was with great difficulty detected; and a spider so closely resembled, in form and color, a black ant, that it was mistaken for that insect. It had, moreover a habit of elevating its fore-legs so as to exactly resemble antennæ. Various species of stinging ants, which no bird would touch, were mimicked by spiders which were not distasteful to birds, as Mr. Belt proved.

So universal is protective resemblance among insects, in Nicaragua, that Mr. Belt was sure that whenever he found a species provided with special means of defense, others imitating it might be found also, and such indeed was the case invariably. It was noticed that insectivorous birds and mammals did not destroy the fire-flies, which were very abundant, and several insects, especially species of cockroaches, mimicked them, and in a perfectly fearless manner made themselves conspicuous, instead of resorting to hiding-places as is the custom of their tribe.

Those insects which were protected by special means of defense exposed themselves without fear, and rather made a display of their qualities. With the brilliant Heliconii butterflies, wasps of rich metallic lustre, fire-flies, and many other species, this was very obvious. Perhaps the display of their destructive features is a warning, otherwise they might be destroyed by their natural enemies, although not eaten. Thus a brilliantly-colored frog would come forth fearlessly during the day when others were concealed, and it was at once assumed that no animal would feed upon it; and, on offering it to fowls and poultry, not one would touch it excepting a duck, which at once threw it down and shook its head with evident dislike. Mr. Belt suggests that the white tail of the skunk laid upon its back makes it conspicuous in the dark, and may be a sort of warning to animals which would do it injury.

A most interesting instance of mimetic appearance and habit was afforded by a green, leaf-like locust. This insect would remain perfectly motionless, exactly resembling a leaf, while its enemies, a species of foraging ants, would run over it, and around it, destroying every insect in their way. The locust might be taken up and dropped again among the ants, still motionless as if dead, thus escaping injury.

These wonderful features in animal life had previously been studied by Mr. Bates in his researches in the valley of the Amazon, and by Mr. Wallace in several works, and strikingly illustrate the possibility of change in the structure and habits of living creatures. If this were not the case, how surely all types of animals and plants would disappear with the change of their environment! Mr. Belt calls attention to the fact that we are not to understand that one animal's imitating another is a conscious act. Perhaps we know very little of consciousness in these lowly creatures, but it is quite certain that they are conscious of danger, experience fear, and impulse to seek safety. Nor can we doubt that in these may originate those modifications which inaugurate protective resemblances which afterward become so marked. Natural selection is the present and efficient means by which the modified forms are preserved; those most favorably modified most readily escape destruction, and thus the fittest survive amid inevitable dangers.

Perhaps all insects have natural enemies which they fear, and this instinct of self-preservation is active and acute; and it would be strange indeed if these conditions found no expression in those modifications of both form and habit which secure safety to the creature, and afford means of defense as well as of attack.

The well-known habit of animals in making their nests or burrows in places of safety was noticed in a species of birds which build their nests in bushes infested by stinging ants: a small parrot builds in a hole made in the nests of the termites, and a small fly-catcher builds alongside of the nests of one of the wasps.

The account given of the foraging ants (*Ecitons*) is most interesting. They live solely on insects and similar prey; ransack houses, and clear them of insects of every kind. They appear to be without fixed abodes, and advance in columns three or four yards wide, with flank, advance, and rear columns, millions in number. Their presence is announced by the noise of birds, as trogons, ant-thrushes, and others, which follow them for the insects which take wing, terrified by their destroyers. Grasshoppers, cockroaches, and others, are seized, bitten in pieces, and the fragments conveyed to the rear of the columns.

The temporary abodes of these ants seem to be a crevice or dense mass of brushwood, but in a few days they are off to new grounds. Small parties ascend trees in search of wasps' nests, and, if found, information is conveyed to the swarms below, when a column ascends, takes possession of the nest, and devours or removes the young, the wasps being powerless before the multitude.

While ants which hunt singly have eyes well developed, the eyes of the *Ecitons* are small, imperfect, and in some species wanting, and they evidently follow each other by scent. This was shown in the following manner: A party or column following a leader will become distracted if his track, which they will follow in its minutest windings, is interfered with. Mr. Belt scraped away the clay which the leader had gone over, and the followers were completely at fault until they had gone around the scraped portion, when, on striking the trail again, their hesitation vanished, and they followed it with the greatest confidence.

They aid each other in difficulty with a sympathy and intelligence that are extraordinary, and overcome dangers of very rare occurrence. On one being partially buried with atoms of clay, the others removed them; a small lump, too heavy for them to move, was instantly bitten to pieces, a dozen or more being summoned to assist. They aid each other in ascending steep places, in crossing water, and in every movement afford evidence of wonderful social order.

Not less interesting than these were the leaf-cutting ants (*Œcodoma*), common in tropical America. Their order, sagacity, and underground abodes, were a subject of wonder and study. All introduced species of trees are directly attacked by them, and, unless carefully watched, are destroyed. Mr. Belt turned the tide of war by pouring a strong solution of carbolic acid, in water, into their formicaries; straightway the hosts left his plants to attend to home-affairs, and the removal of dead ants, food, and undeveloped larvæ and pupæ from their dwellings to a new home, was carried on with extraordinary zeal. The old burrow was deserted, and their ravages for a time suppressed. Corrosive sublimate makes the ants mad and furious. A little of the powder was sprinkled in one of their paths; so soon as the ants touched it, they ran wildly about attacking others, and very soon compact masses, or balls of ants, would be found biting each other. Huge fellows from the formicaries, measuring three-quarters of an inch in length, came forth to set matters right, but on touching the poison their bravery forsook them. They attacked others, and were themselves attacked, and became the centres of balls of furious ants.

Many indigenous trees escape their ravages, evidently because distasteful. Through long ages the ants and trees of tropical America have become somewhat modified together. All plants disliked by ants have a great advantage over others, and thus a selection has gone on, in which introduced species do not share. The lime is less liked than the orange or the citron, and, while these are inevitably destroyed, unless protected, the lime would probably survive; and Mr. Belt judiciously remarks that a little more or less acridity, or a slight chemical difference in the composition of the tissues of a leaf, so small that it is inappreciable to our senses, may be sufficient to insure the preservation or the destruction of a species throughont an entire continent. The paths of these ants ramify in every direction from their abodes, and are more thronged than the streets of London. They seek the open spaces near margins of the forest, and excavate a series of galleries, which are the scene of manifold operations. Continually the workers bring in burdens consisting chiefly of fragments of leaves. Naturalists have differed as to the use to which these leaves are put. Some suppose they are used as food, others, to line their galleries; the explanation given by Mr. Belt is, that the leaves are used as a manure, on which grows a minute fungus, which is the food of the ants; that they are, in reality, mushroom growers and eaters. This extraordinary conclusion he arrived at by careful observations. He repeatedly explored their nests, which are a series of rounded chambers about as large as a man's head, connected by tunneled passages leading from one chamber to another. In the burrows the leaves could never be found in quantity; they were evidently directly used up; but the chambers were about three-fourths filled with a speckled-brown, spongy-looking mass. Throughout this were ants with pupæ and larvæ. Upon careful examination, it proved to be minutely subdivided leaves, brown and withered, overgrown and lightly connected by a minute, white fungus, that ramified in every direction through it. This fungus was found in every chamber opened, and in the midst of it ant-nurses and immature ants. When the nests were disturbed, this fungus, or ant-food, was guarded with great care, and every atom of it was removed as soon as possible, if the old abode was broken up. That the leaves were not eaten was shown by the fact that the refuse in many deserted chambers was composed entirely of their decayed fragments, exhausted as a manure for the fungus, and left as food for larvæ of several species of beetles. Some leaves were evidently unsuited to the purposes of the ants. Grass, if carried in, was directly brought out again, and thrown away. The carriers of this were probably young ants, and may have got a severe ear-wigging for their stupidity. After all, then, do ants, like hosts of other animals, learn by experience, and is instinct, so called, sometimes at fault?

Bates describes the sand-wasps, on the banks of the Amazon, which, on making a hole, carefully examine the locality before leaving it to procure food, and Mr. Belt noticed similar actions in repeated instances. They take the same precautions that a man would do, who wished to return to the same spot. Frequently, after going a few rods, they will return, fly around for an instant, and then dart away. On one occasion, a portion of a green caterpillar was carried away by a wasp, which, on returning for the other portion, missed its mark on alighting, and became quite lost, when it took wing again, made circles around the spot, and again alighted, but in vain. This was repeated half a dozen times, and the insect seemed to get angry, buzzing loudly, when finally it found its prey.

Butterflies of several kinds are described as abundant, but the migration in enormous swarms of one or more species, which occurred every year, is an interesting phenomenon.

Flights of butterflies were thus described by Darwin in 1832: "When off the shores of Northern Patagonia, we were surrounded by vast numbers of butterflies, in bands or flocks of countless myriads, extending as far as the eye could range; even with the aid of a telescope, it was not possible to see a space free from butterflies." Mr. Belt had seen immense migrating flocks in Brazil, journeying southeastward, as were all those seen by him in Nicaragua. These were a brown-tailed species (*Timetes chiron*), and there were no return-swarms, but a continuous migration in one direction only. The gilded, day-flying moth (*Urania leilus*), and a few yellow butterflies, were seen with the migrating hosts.

Birds, which are abundant at all seasons in the country, have a habit of associating, possibly for safety, or, as Mr. Belt suggests, to assist each other in hunting for food. Thus, flocks of hundreds, comprising a score of different species, are frequent, and, when present, the trees seem alive with them. He could scarcely go abroad without meeting them; fly-catchers, woodpeckers, tanagers, creepers, trogons of several species, all associating, apparently, on the most friendly terms, for mutual help.

The natives found about the country, as well as in the towns, represent an inferior type of civilization. They are, as a rule, excessively indolent and thriftless, the mixed races much more so than the native Indians. Idleness is the curse of Central America, and the people are content to live in squalid poverty rather than work. Dio Filiberto was a thrifty man, and told the traveler that he was building a new residence, and showed him outside his hut four old posts, used for tying cows to, which had evidently been in the ground many years. "There," said he, "are the corner-posts, and I shall roof it with tiles." Long, no doubt, will he lounge at evening, when his wife and children are milking the cows, and feel proud, as he views the four old posts, that he is building a new house.

The habitations of the Indians, mere shelters as they are, are generally quite cleanly; and this class of the population is invariably fond of flowers. On all important occasions, beautiful and fragrant flowers are used for decoration, a trait of the old Indians which survives with their unfortunate descendants.

Mr. Belt's descriptions of natural scenery are vivid and impressive. The night-world he describes as being very different from that of the day. Things that blink and hide from the light are all awake and astir when the sun goes down. Great spiders and scorpions prowl about, or take up advantageous positions where they expect their prey to pass. Cockroaches, of all sizes, from that of one's finger to that of one's finger-nail, stand with long, quivering antennæ, watching for their numerous foes, or scurry away from danger, as fast as their legs can carry them; but, if they come within reach of the great spider, they are pounced upon in an instant, and, with one convulsive kick, give up the struggle. Centipedes, wood-lice, and all kinds of creeping things, come out of cracks and crevices; the pools are alive with water-beetles, which have been hiding in the ooze all day. Owls and night-jars make strange, unearthly cries. The timid deer comes out of its close covert to feed on the grassy clearings. Jaguars, ocelots, and opossums, slink about in the gloom. All the day-world is at rest and asleep. The night speeds on; the dawn is saluted by the song of birds, and the creatures of night hurry to their dens and hiding-places. As a traveler, naturalist, and observer, Mr. Belt has done excellent service, and the reading world is his debtor.

A GIGANTIC RELIC.

By H. BUTTERWORTH.

THE rarest collections of scientific relics are often the most unvisited, and it is a somewhat singular fact, that the choicest and most instructive curiosities in many of our larger cities are not to be found in the popular museums. Thousands of people living in the city of Boston, who are familiar with the stuffed animals and astonishing wax figures in the old Boston Museum, and are accustomed to air their fancy among the respectable fossils and gorgeous tropical birds in the Museum of Natural History, have perhaps never so much as heard of the wonder-exciting collection of anatomical curiosities known as the Warren Museum. The building stands on Chestnut Street, a quiet, tenantless alley, running from Charles Street to the Charles River, but a few steps from Beacon Street and the Public Garden. It is made of brick, with heavy iron doors and shutters, and of all places would be the least likely to attract the eye of the stranger, but for the inscription over the door—

"ERECTED BY

DR. JOHN COLLINS WARREN."

Dr. John Collins Warren was the son of Dr. John Warren, a most skillful surgeon in the American army during the Revolutionary War, and the founder of the medical school in Harvard College. He was educated in the best medical schools of London and Paris, and, on the death of his father, in 1815, was elected Professor of Anatomy and Surgery at Harvard College, and in 1820 was placed at the head of the surgical department of the Massachusetts General Hospital, a position that he held for thirty-three years. During the latter period he made the most extensive collection of anatomical specimens to be found in the country. A part of these are still at the Massachusetts General Hospital, a part at the Boston Museum of Natural History, and a part, comprising the rarest and most valuable, constitute the Warren Museum.

The museum belongs to Dr. Warren's heirs. For a considerable period after his decease, they used to open it on certain days to the public, but it ceased to excite curiosity, and it is now only opened by special permission, on application to members of the family. Every courtesy is extended to those who wish to visit the place for scientific purposes, although no provision was made in Dr. Warren's will for the preservation of the relics or care of the building.

The curiosities collected by Dr. Warren, which are to be seen in the Boston Museum of Natural History, are comparatively unimportant. The biography of the highwayman, Walton, bound in his own skin, attracts the lovers of sensation, and the cast of the French horned lady, and the skeletons of certain rickety Indians, seem to be particularly appetizing to children. The anatomical specimens, showing how near a person may come to death, and yet escape, are, however, interesting. Among these, is the cranium of the once famous Vermonter, who lived twelve years and a half after the passage of an iron bar through his head, the consequence of an accident in blasting rocks. He used to travel about New England, exhibiting himself and his bar. He died in California about the year 1860. The bar was three feet seven inches in length, and 1¼ inch in diameter, and weighed 13¼ pounds. It is placed near the cranium, in the museum.

The Warren Museum consists of two fire-proof rooms, one of which contains gigantic fossils, and the other, relics which the great anatomist wished to preserve with more than ordinary care. Among these are the skull, brain, and heart of Spurzheim, the phrenologist and anatomist, who died in Boston in 1832, and whose monument graces one of the principal avenues of Mount Auburn.

Spurzheim was a martyr to science, and those who were familiar with his self-forgetful life, and the vicissitudes of his career, could hardly view these relics with unmoistened eyes. The heart is preserved in a glass jar of alcohol, and the brain in a glass box filled with liquid. The Prussian philosopher died only two months after his arrival in Boston, during the delivery of his first course of lectures. He gave his body to science, to which, from boyhood, he had devoted all the energies of his soul.

The most remarkable object in the Warren Museum is the largest skeleton of the *Mastodon giganteus* ever discovered on the continent. By its side, in way of contrast, is the frame of the elephant Pizarro, the largest ever brought to this country. The skeleton of the *Mastodon giganteus* will not fail to cause the visitor to start back in awe, and he will be hardly able to suppress that adjective of fools, "Impossible!" It is twelve feet high, and thirty-four feet in length, from the tips of the tusks to the extremity of its tail. Its trunk is seventeen feet in length. The animal must have weighed more than 20,000 pounds!

Dr. Warren, in his magnificent and very costly work on the *Mastodon giganteus*, copies of which are only to be found in the rarest libraries, has given us an account of all that is known of this animal, and a very interesting description of the finding of this particular specimen, of which we make an abridgment:

At a very early period after the settlement of this country, relics of the mastodon were found in the vicinity of the Hudson River. Among these were a tooth, which is described by Dr. Cotton Mather, of Boston, as weighing more than four pounds, and a thigh-bone, said to have been more than seventeen feet long.

As the country became settled, mastodon-bones, in greater or less numbers, were found scattered over a large part of the territory of the United States, but chiefly near the Hudson, in the salt-licks of Kentucky, in the Carolinas, in Mississippi and Arkansas. They have recently been found in California and Oregon.

The Hudson River country, between New York and Albany, seems to have been a favorite resort of the mastodon race. The lands here were fertile, undulating, and well wooded, and the valleys contained lacustrine deposits, favorable to the growth of such trees and shrubs as would be likely to afford this animal subsistence.

In the year 1845 there was found, at Newburg, on the Hudson, the largest perfect skeleton of a mastodon which has yet been exhumed on this continent. The summer had been exceedingly hot and dry. Many small lacustrine deposits had been exposed by the drought, and the farmers had industriously seized upon the opportunity to remove these rich beds of fertility to their tillage-lands and fields.

The drought at last laid bare one of these deposits in a bog on the farm of Mr. N. Brewster, a spot that had never been known to become dry before. Mr. Brewster at once summoned his men to remove the deposit, as rapidly as possible, to his fields and farm-yards. One day, toward evening, in the latter part of summer, these laborers struck a hard substance. Some said it was "a rock;" others, a "log;" others, jestingly, "a mammoth."

Early the next morning, Mr. Brewster went with his laborers to the field, and found the supposed rock or log to be an immense bone. The men began digging, full of eager curiosity, and exposed to view the massive skull and long white tusks of a mastodon. These tusks were of such immense size and length as to cause the most wonderful reports to go flying about the neighborhood, and to draw the good people of Newburg in crowds to the place. It was soon discovered that the perfect skeleton of a mastodon was embedded in the peat. Sheer-poles and tackles were obtained, and, amid excitement, cheering, and many cautions, the bones of the monster were raised from the bed where they had lain no one can tell how many thousand years.

Two days were occupied in these interesting labors. The relics drew to them an immense number of people from the surrounding country. Beneath the pelvic bones of this mastodon were found five or six bushels of broken twigs, which evidently had constituted the animal's last meal. He had undoubtedly been mired while attempting to cross this bog, and in this manner perished. These twigs were from one-quarter to three-eighths of an inch in diameter, and a little more than an inch in length. They were supposed to belong to the willow, linden, and maple trees.

It is impossible to conjecture how many years ago this creature may have lived. What marvelous scenes must have passed before its eyes in its wanderings! What gigantic forests; what noble water-courses; what luxurious vegetation; what strange animals may have been its companions—species that passed away long before civilization brought its destructive weapons to the Western shores! Was man, too, its contemporary; if so, how humiliating to intellectual pride is the oblivion that consigns to conjecture and mystery so large a portion of the human race!

EVOLUTION AND THE DOCTRINE OF DESIGN.[1]

By W. STANLEY JEVONS, F.R.S.

VERY profound philosophers have lately generalized concerning the production of living forms, and the mental and moral phenomena regarded as their highest development. Mr. Herbert Spencer's theory of Evolution purports to explain the origin of all specific differences, so that not even the rise of a Homer or a Beethoven would escape from his broad theories. The homogeneous is unstable and must differentiate itself, says Spencer, and hence comes the variety of human institutions and characters. In order that a living form shall continue to exist and propagate its kind, says Mr. Darwin, it must be suitable to its circumstances, and the most suitable forms will prevail over and extirpate those which are less suitable. From these fruitful ideas are developed theories of evolution and natural selection which go far toward accounting for the existence of immense numbers of living creatures—plants and animals. Apparent adaptations of organs and limbs to useful purposes, which Paley and other theologians regarded as distinct products of creative intelligence, are now seen to follow as natural effects of a constantly-acting tendency. Even man, according to these theories, is no distinct creation, but rather an extreme specimen of brain-development. His nearest cousins are the apes, and his pedigree extends backward until it joins that of the lowliest zoophytes.

The theories of Darwin and Spencer are doubtless not demonstrated; they are, to some extent, hypothetical, just as all the theories of physical science are to some extent hypothetical, and open to doubt. But I venture to look upon the theories of evolution and natural selection, in their main features, as two of the most probable hypotheses ever proposed, harmonizing and explaining, as they do, immense numbers of diverse facts. 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.

Granting all this, I cannot for a moment admit that the theory of Evolution will alter our theological views. That theory embraces several laws, or uniformities, which are observed to be true in the production of living forms; but these laws do not determine the size and figure of living creatures, any more than the law of gravitation determines the magnitudes and distances of the planets. Suppose that Darwin is correct in saying that man is descended from the Ascidians;

[1] Abstracted from the closing chapter of "The Principles of Science: A Treatise on Logic and Scientific Method."

yet the precise form of the human body must have been influenced by an infinite train of circumstances affecting the reproduction, growth, and health, of the whole chain of intermediate beings. No doubt, the circumstances being what they were, man could not be otherwise than he is; and, if, in any other part of the universe an exactly similar earth, furnished with exactly similar germs of life, existed, a race must have grown up there exactly similar to the human race.

By a different distribution of atoms in the primeval world, a different series of living forms on this earth must have been produced. From the same causes acting according to the same laws, the same results will follow; but from different causes acting according to the same laws, different results will follow. So far as we can see, then, infinitely diverse living creatures might have been created consistently with the theory of evolution, and the precise reason why we have a backbone, two hands with opposable thumbs, an erect stature, a complex brain, two hundred and twenty-three bones, and many other peculiarities, is only to be found in the original act of creation. I do not, any less than Paley, believe that the eye of man manifests design. I believe that the eye was gradually developed; and we can, in fact, trace its gradual development from the first germ of a nerve affected by light-rays in some simple zoophyte. In proportion as the eye became a more delicate and accurate instrument of vision, it enabled its possessor to escape destruction; but the ultimate result must have been contained in the aggregate of the causes, and these causes, so far as we can see, were subject to the arbitrary choice of the Creator.

Although Prof. Agassiz is clearly wrong in holding that every species of animals or plants has appeared on earth by the immediate intervention of the Creator, which would amount to saying that no laws of connection between forms are discoverable, yet he seems to be right in asserting that living forms are entirely distinct from those produced from purely physical causes. "The products of what are commonly called physical agents," he says,[1] "are everywhere the same (i. e., upon the whole surface of the earth), and have always been the same (i. e., during all geological periods); while organized beings are everywhere different and have differed in all ages. Between two such series of phenomena there can be no causal or genetic connection." Living forms, as we now regard them, are essentially variable. Now, from constant mechanical causes, constant effects would ensue. If vegetable cells are formed on geometrical principles, being first spherical, and then by mutual compression dodecahedral, then all cells should have similar forms. In the *Foraminifera* and some other of the more lowly organisms, we do seem to observe the production of complex forms on pure geometrical principles. But from similar causes, acting according to similar laws and principles, only similar results could be produced. If the original life-germ of each creature is a

[1] Agassiz's "Essay on Classification," p. 75.

simple particle of protoplasm, unendowed with any distinctive forces, then the whole of the complex phenomena of animal and vegetable life are effects without causes. Protoplasm may be chemically the same substance, and the germ-cell of a man and of a fish may be apparently the same, so far as the microscope can decide; but if certain cells produce men, and others as uniformly produce a given species of fish, there must be a hidden constitution determining the extremely different results. If this were not so, the generation of every living creature from the uniform germ would have to be regarded as a distinct act of arbitrary creation.

Theologians have dreaded the establishment of the theories of Darwin and Spencer, as if they thought that those theories could explain every thing upon the purest mechanical and material principles, and exclude all notions of design. They do not see that those theories have opened up more questions than they have closed. The doctrine of Evolution gives a complete explanation of no single living form. While showing the general principles which prevail in the variation of living creatures, it only points out the infinite complexity of the causes and circumstances which have led to the present state of things. Any one of Mr. Darwin's books, admirable though they all are, consists but in the setting forth of a multitude of indeterminate problems. He proves in the most beautiful manner, that each flower of an orchid is adapted to some insect which frequents and fertilizes it, and these adaptations are but a few cases of those immensely numerous ones which have occurred throughout the life of plants and animals. But why orchids should have been formed so differently from other plants, why any thing, indeed, should be as it is, rather than in some of the other infinitely numerous possible modes of existence, he can never show. The origin of every thing that exists is wrapped up in the past history of the universe. At some one or more points in past time there must have been arbitrary determinations which led to the production of things as they are.

The following article, upon the same general subject, recently appeared in *Church and State:*

The last lecture in the course on "Christian Truth and Modern Opinion" was delivered in Christ Church, New York. The subject was, "Evolution and a Personal Creator." Dr. Smith commenced by saying that while he was very far from being an advocate for the theory of evolution, it was no part of his purpose to attempt its refutation. He expressed the opinion, judging from former conflicts between religious and scientific theories, and the evident tendency of scientific investigation and discovery, that not many years would pass away before some theory of evolution would be generally accepted by educated men as the most rational explanation of the phenomena of the universe. In the mean time the minds of many persons are seriously disturbed by the supposed antagonism of any such theory to the idea of a personal God, and therefore to the whole idea of natural and revealed religion. It is very important, therefore, that, in anticipation of the general acceptance of some such theory, it should be shown that it not only does not militate against the idea of a personal God, but that it is hostile to no interest of Christianity.

In carrying out this purpose, Dr. Smith said that he should seek, as a starting-point, some ground which could be held in common by theists who are without prejudice in regard to scientific investigation, and evolutionists who are ready to consider any evidence as to the Infinite Being behind and beyond the phenomena of Nature.

In seeking such common ground, Dr. Smith referred to that period, in the history of Nature, when space was filled with a homogeneous mass which the Greeks called *hyle.* Whether this was what we usually call matter, or immeasurably extended force-centres, made no difference in the argument. Beyond this *hyle*, and preceding it in the order of thought, is absolute being. The theist, of course, holds this. Mr. Herbert Spencer, the great leader of the evolutionists, holds it also. We must postulate absolute being, he says, as the condition of any conclusions as to phenomena. The evolutionist holds, however, that every thing in regard to absolute being is unknowable. If it is unknowable, then he can no more deny than affirm any thing in regard to it. Dr. Smith then said, that since the evolutionist, on his own principles, could not deny it, he should suppose, for the present, reserving the evidence for it until later in the discussion, that absolute being is personal being, with reason, affection, and will.

Dr. Smith then said that, having made this supposition, which no evolutionist could deny, we were prepared to witness the process of evolution, so far as such a process exists in Nature, remembering all the time that the whole process and every step in the process are simply expressions, according to our supposition, of the will and agency of the Absolute Being.

We find certain laws in Nature (which is only another name for methods of divine agency), by which this process of evolution is carried on. Such are the laws of the persistence of force, the continuity of motion, and the indestructibility of matter. The divine power, working according to these laws, builds up the system of the universe. Dr. Smith showed how, on the theory of evolution, the apparent chasm between inorganic and organic Nature might be passed over without disturbance or any different or peculiar divine agency. In other words, the process might be continuous without militating at all against the idea of the constant agency of a personal God. The evidence alleged by evolutionists that this is the case, and that the process comes finally to include men, was considered. The objections also to this evidence were reviewed. In this connection Dr. Smith paid a high tribute to the scientific labors and the theistic principles and influence of Prof. Agassiz, expressing the conviction, at the same time, that Prof. Agassiz's scientific opinion as to the origin of species represented a failing cause.

The objection arising from the absence of uniting links in the fossiliferous remains of species was considered, and the refutation claimed to be made by the evolutionists was given in detail. This answer to the objection is found in the fact of the imperfection of the geological record, and the almost entire destruction of organic remains. The evolutionist claims that if it were not for the law by which less favored varieties of animal life disappeared, the breaks between species would not exist. Specific distinctions would be impossible. In this connection Dr. Smith considered the basis of specific classification, giving a review of the old controversy between nominalism and realism on this subject. He also pointed out how certain laws—such as those of the transmission of likeness to an original type; the tendency to variation; the increase of animal life in a geometrical ratio; and the consequent struggle for existence—would, according to the theory of evolution, give rise to the phenomena of specific distinction.

At this point Dr. Smith claimed that, if it should finally be established that this progress in Nature is continuous until it reaches and includes man, it would no more militate against the idea of a personal Creator than the fact that the process of evolution existed at all. If God has chosen that any part of the process shall be without distinct and special creative acts, there is no reason why the whole process may not be, and the continuous chain of evolution run back to the one original creative act. It must be remembered, however, that the argument proceeds all the time upon the supposition of an incessant and ubiquitous exercise of the will and the agency of a personal God, in every atom of matter, or every force-centre, and thus underlying and pervading the whole phenomenal universe.

As the theory of evolution touches only phenomena and the laws of their succession, it excludes no hypothesis as to what lies back of phenomena, and the existence of a personal God must be assailed, if assailed at all, upon other and metaphysical grounds.

Dr. Smith remarked that, although the subject assigned him required him to consider merely the relation between the theory of evolution and the doctrine of a personal Creator, yet, inasmuch as it was his desire to show that even if the theory is true it affects no interest of Christianity injuriously, he would say a word in regard to the Scriptural account of the creation. The interpretation of the Bible is more or less modified in each succeeding age, and is thus more and more correctly understood. The Bible has passed through the crisis of astronomical and geological investigation, and its authority is not only unimpaired, but is increased by the ease with which it is found to be adapted to every stage of scientific progress. Certain peculiarities in Hebrew words used in describing the creation were here referred to.

Up to this point the existence of a personal Creator had been placed in the argument upon hypothetical ground. Dr. Smith then considered the evidence upon which this truth rests, drawing a distinction between the understanding and reason, affirming the intuitional power of reason and following the line of the great philosophers like Coleridge, Kant, Leibnitz, and Plato. A rational plan in the universe made every supposition irrational except that of a reason preceding phenomena and upon which phenomena rest.

Supposing, then, that the theory of evolution should finally be established, we find in Christianity the completion of the process, by the union of man with God in the Incarnation. This view, which presents all things as complete in Christ coming from Him and returning to Him, gives a grandeur to Nature which it cannot otherwise possess. Dr. Smith closed with a quotation from Coleridge's "Hymn in the Valley of Chamouny."

SKETCH OF DR. J. P. JOULE, F. R. S.

IF the discovery of chemical analysis by means of the spectrum be accepted as the most brilliant scientific achievement of the present century, the research by which the conservation of energy became established on a basis of exact quantitative experiment must be regarded as far more profound and important in its consequences. This great generalization, beyond doubt, is the property of no single intellect. Many men, in different countries, had independently arrived at the conception, and had furnished various kinds and degrees of evidence that it was true, but the honor of its first experimental demonstration, by which the quantitative convertibility of forces may be established, belongs to the subject of the following sketch.

JAMES PRESCOTT JOULE was born at Salford, England, on Christmas-eve, 1818, and was privately educated at home. He early showed a taste for scientific study, and, at the age of fifteen, became a pupil of Dr. John Dalton, the chemist. This celebrated man—atomist and Quaker—came to Manchester, and became Professor of Mathematics and Natural Philosophy in the New College; and, when that was removed to York, he remained as a private teacher of the same subjects. By him, young Joule was initiated into mathematics, and trained in the art of experiment.

Mr. Joule's attention was early turned in a direction which naturally led him to his great discovery. At an early age he took up the subject of electro-magnetic engines; the idea of using electricity as a motive power being then a favorite one among scientific men. He made inventions to employ electro-magnetic force as a motor, and his first scientific paper was upon this subject. But the result of his investigations was the abandonment of any expectation of obtaining a valuable power from electro-magnetism. But, while giving up the hope of arriving at any important economical conclusions, Mr. Joule continued his researches on the laws which govern the lifting and sustaining power of the electro-magnet. Early in 1841 he gave, in the form of a lecture in the Royal Victoria Gallery, Manchester, the result of his experiments on a new class of magnetic forces, with the preliminary statement of what had been done by M. Jacobi, of St. Petersburg, and himself, in the way of applying magnetism as a motive power. Mr. Jacobi, it may be remarked, is reputed to have been the first who constructed an electro-magnetic machine capable of producing continuous movement, and which was for a long time used in impelling a boat on the Neva.[1] Mr. Joule subsequently continued this investigation in conjunction with Dr. Scoresby, and from the results of their calculations it appeared that a grain of coal consumed by a steam-engine will raise 143 pounds one foot high, while a grain of zinc consumed in a voltaic battery can raise theoretically only 80 pounds. The cost of power by electro-magnetism was estimated to be twenty-five times greater than the cost of an equal amount of steam-power. Mr. Joule had arrived at the theory of the magnetic engine when twenty-one years of age, and in 1840 he had published a paper in Sturgeon's "Annals of Electricity," demonstrating that there is "no variation in economy, whatever the arrangement of the conducting metal, or whatever the size of the battery." Kindred to the subject of electro-motive machines is that of the air-engine, to which Mr. Joule gave considerable attention.

"Dr. Joule has pursued several lines of inquiry conjointly with other philosophers. His communication to the Royal Society, 'On the Changes of Temperature produced by the Rarefaction and Condensation of Air,' in which he pointed out the dynamical cause of the principal phenomena, and described the experiments on which his conclusions were founded, led Prof. Thomson, of Glasgow, to embark with Dr. Joule in a series of elaborate investigations 'On the Thermal Effects of Fluids in Motion.' The first of their series of four papers was read before the Royal Society, in June, 1853; the last in June, 1862. The whole will be found published at length in the 'Philosophical

[1] Since Jacobi's elaborate experiments, many other electro-motors have been constructed. The late Mr. Sturgeon, of Manchester, with whom Mr. Joule corresponded in his early inquiries, pumped water with an electro-magnet; Mr. Davidson, of Aberdeen, drove a turning-lathe by the same power; and in 1848 Sir David Brewster sailed at the rate of a mile an hour in a boat thus impelled, and constructed by Mr. Dillwin, of Swansea. In this country Messrs. Davenport and Cook investigated the subject.

Transactions.' Dr. Lyon Playfair and Dr. Joule have also published an account of a conjoint investigation into the volumes occupied by bodies, both in the solid form and when dissolved in water, and have obtained results of an unexpected nature as well as of great value. Among other curious results, they found that 'many salts, when dissolved in water, do not add to the bulk of the water more than is due to the water actually present in the salts.' They have further shown that 'when salts do add to the bulk of the water in which they are dissolved, the increase of the bulk corresponds to that of a volume, or some multiple of a volume of water.' "

Dr. Joule's inventive talent was early shown in the construction of galvanometers. In 1863 he described to the Manchester Society his new and extremely sensitive thermometer, which was able to detect the heat radiated by the moon. When the moonbeam passed gradually across the instrument, the index was deflected several degrees, first to the right and then to the left; thus showing that the air in the instrument had been heated a few ten-thousandths of a degree by the influence of the rays. These experiments were lately referred to by the present Earl Rosse in a lecture on the same subject delivered at the Royal Institution.

It was about 1840 that Dr. Joule began to direct his special attention to the subject of heat. He made a communication to the Royal Society in that year, announcing the discovery of a principle in the development of heat by the voltaic principle, in which he established relations between heat and chemical affinity. This paper is recognized as containing the germ of the subsequent unfoldings of dynamical science in relation to chemical action.

The old view of the nature of heat still prevailed, although the declarations of Bacon and Locke, and the researches of Rumford and Davy, had undermined the notion that heat was a subtile matter or material agent diffused throughout all bodies, and had prepared the way for its apprehension as a mode of molecular motion. The first noteworthy advance toward the establishment of the mechanical theory of heat was made by Séguin, a Frenchman, in 1839, and by Mayer, a German, in 1842, who had propounded the hypothesis that the heat evolved in compressing an elastic fluid is exactly equivalent to the compressing force. But the theory was not yet established upon an experimental basis, so as to command the assent of the scientific world.

Independently of what had been done by others, and working in his own line, Dr. Joule had established relations, as we have seen, between heat and chemical affinity in 1840, and, some two years later, he applied the dynamical theory to steam-engines, to electro-magnetic engines, to vital processes, and to chemistry. "His paper on the 'Electric Origin of Heat' was a first communication, in 1842, to the meeting of the British Association at Manchester—the last meeting, by-the-way, at which Dalton appeared; and, on August 21, 1843, a circumstance which requires special mention, he communicated a second paper to the Association, then meeting at Cork, in which he describes a series of experiments on magneto-electricity, executed with a view to determine the mechanical value of heat. Experiments, with a like object, on the condensation of air, were communicated to the Association in 1844; and in 1845 his important paper, 'On the Mechanical Equivalent of Heat,' detailed the results he had gained from water agitated by a paddle-wheel. In following years, the same subject was perseveringly prosecuted, by numerous and yet more accurate experiments, until his grand determination was finally reached. In an elaborate paper, read before the Royal Society, January 21, 1849, and published in the 'Philosophical Transactions' of 1850, we have the results thus stated: 1. 'The quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the quantity of force expended;' 2. 'The quantity of heat capable of increasing the temperature of a pound of water by 1° Fahr., requires for its evolution the expenditure of a mechanical force required by the fall of 772 pounds through the space of one foot.'"

Dr. Tyndall gives the following explanation of the term "foot-pounds," used as a measure by Joule: "The quantity of heat which would raise one pound of water one degree in temperature is exactly equal to what would be generated if a pound-weight, after having fallen 772 feet, had its moving force destroyed by collision with the earth. Conversely, the amount of heat necessary to raise a pound of water one degree would, if applied mechanically, be competent to raise a pound-weight 772 feet high, or it would raise 772 pounds one foot high. The term 'foot-pound' expresses the lifting of one pound to the height of a foot. Thus the heat required to raise the temperature of one pound of water one degree being taken as a standard, 772 foot-pounds constitute what is called *the mechanical equivalent* of heat."

A sharp controversy arose a few years since in England as to the relative merits of Mayer and Joule in contributing to the establishment of the truth of the mechanical equivalent of heat. Dr. Joule states his own relation to the investigation as follows: "Mayer," he says, "appears to have published his views for the express purpose of securing priority. He did not wait until he had the opportunity of supporting them by facts. My course, on the contrary, was to publish only such theories as I had established by experiments calculated to commend them to the scientific public, being well convinced of the truth of Sir John Herschel's remark, that 'hasty generalization is the bane of science.' . . . I therefore fearlessly assert," writes Dr. Joule, in August, 1862, "my right to the position which has been generally accorded to me by my fellow-physicists, as having been the first to give decisive proof of the correctness of this theory."

Prof. Tyndall, although the English champion of Mayer's claims, did ample justice to his own countryman, as the following passage shows: "It is to Mr. Joule, of Manchester, that we are almost wholly indebted for the experimental treatment of this subject. With his mind firmly fixed on a principle, and undismayed by the coolness with which his first labors appear to have been received, he persisted for years in his attempts to prove the invariability of the relation between heat and ordinary mechanical force. He placed water in a suitable vessel, agitated it by paddles moved by measurable forces, and determined the elevation of temperature; he did the same with mercury and sperm-oil. He caused disks of cast-iron to rotate against each other, and measured the heat produced by their friction. He urged water through capillary tubes, and measured the heat thus generated. The results of his experiments leave no doubt upon the mind that, under all circumstances, the absolute amount of heat produced by a definite amount of mechanical force is fixed and invariable."

For this great scientific achievement the Royal Medal of the Royal Society was awarded to Mr. Joule in 1852; and eight years later, when men of science began more fully to apprehend the great value of the discovery, he was presented also with the Copley Medal of the Royal Society. On that occasion, Sir Edward Sabine, the president, alluding to the former award, used the following words: "Both awards refer to the same experiments, and are substantially for the same great step in natural philosophy. You are all aware that a great principle has been added to the sum of human knowledge—one fruitful in consequences in a thousand ways, and which, being accepted among undisputed truths, is now embodied, without question, alike in the most wide-ranging speculations and the most matter-of-fact practice. The award of two medals for the same researches is an exceedingly rare proceeding in our society, and rightly so. The council have, on this occasion, desired to mark by it, in the most emphatic matter, their sense of the special and original character and high desert of Mr. Joule's discovery. No words of mine could add to the value of the award."

Dr. Joule has figured but little in the fields of popular science, having only given a few lectures to the people in Manchester, and published no book, as we are aware, of any kind. But his contributions to scientific periodicals and the transactions of learned societies are very numerous, and give the results of prolonged and incessant original investigations, extending through many years. He became a Fellow of the Royal Society in 1850, received the degree of B. C. L. from Oxford, of LL. D. from the Universities both of Dublin and of Edinburgh, is a corresponding member of the Institute of France, and was President-elect of the British Association for the Advancement of Science, which met at Bradford last year.

EDITOR'S TABLE.

A FOREIGN LESSON AND A DOMESTIC APPLICATION.

THE celebrated Tichborne case, now closed in England, has one aspect which is as full of instruction for us as for the people among whom it occurred. The leading facts have been often printed, but, as the proceedings dragged through several years, it may be well to make a brief summary of the main facts involved in it. Roger Charles Tichborne was born in 1829, and was heir to a baronetcy and an immense English estate, yielding a revenue of $100,000 a year. His parents were an ill-assorted couple, of English origin and French connection, habitation, and language. The father is represented as weak, and the mother indolent, selfish, and willful. The family was Roman Catholic, and the boy passed through the hands of priests and tutors in Paris, and afterward attended school at Stonyhurst. He then entered the army, where he remained three years, when, tired of home, he resolved to travel, and, after visiting various ports in South America, disappeared, and is supposed to have been lost by the sinking of a ship at sea in the spring of 1854. His personality was peculiar and marked. Slender in *physique*, and with the manners of a gentleman, he had a half-French and half-English education, and "his examinations, his regiments, his barracks, his instructions, his drills, his peculiarities on parade, in the mess-room, or in quarters, his favorite novels, his amusements, his French songs, his topics of conversation, his associates, the cut of his clothes, the style of his boots, his whips, his fowling-pieces, his tobacco-pipes, his days of leave, his twitching, and his peculiar rendering of the words of command," were well known, and perfectly remembered by his associates. He was, besides, a copious letter-writer, and when in the New World kept a full journal, often copying it several times, and sending it home in the form of letters to his mother and aunt. "There was no change noticeable in him before leaving home, or any tendency to alteration of person, gait, or expression, nor any symptom that he was becoming less of a gentleman, or inclined to descend to a lower and freer social stratum."

The disappearance and supposed death of Roger placed his proud and willful and half-insane mother in an unpleasant position in regard to the estate, which would go to the child of a detested daughter-in-law. The disappointment became a possession, a frenzy, and she was determined not to endure it. She accordingly advertised in Australia for information regarding the missing heir of the Tichborne estate. It was a promising region in which to find one: as the London *Times* remarks. "A very large class there are more or less adventurous, taking the license and claiming the immunities of that character. Often changing employment and companionship, and filling up the gaps as they know best, they meet at stations, at diggings, at the bars of hotels, hearing and telling wild, disjointed, strangely-transmuted legends of that old home in the Northern Hemisphere, to them a wonder-land, a romance, and a tradition. It is always the strangest that travels the farthest, and what they do hear of the Old Country is just that which we regard as the least fair sample of it. They are also great novel-readers, and, while they read in shilling volumes numerous stories of patrimonies going a-begging, heirs lost and found, and clever men making their way to the palace from the dunghill, they are also told that 'truth is stranger than fiction,' and, what is more, that audacity is sometimes found better than either." And so the desperate mother "had it published out there that there were good grounds for believing her son, the heir of a splendid patrimony, to have survived a wreck off the coast of South America, where he had been traveling, and to have possibly found his way to Australia, where, for reasons of his own, he might have changed his name, assumed a disguise, and adopted some common occupation."

The advertiser found her customer. There was an adventurer in Australia, Arthur Orton by name, although passing under another cognomen, a butcher and stock-driver, who had sailed about the Atlantic and Pacific, had visited the places where Roger Tichborne had been, had had various occupations, was a kind of Catholic, and an adept at duplicity. He announced himself as Sir Roger Tichborne, the sole survivor of the lost Bella, who was picked up and taken to Australia by another vessel, which with all its crew had quite vanished out of existence. The case would seem to have been unpromising. The claimant was a fat, clumsy, ignorant, low-bred vagabond, who did not understand a word of French, and could not write a note without twenty vulgar blunders, and for twelve months after he gave himself out as Sir Roger he was ludicrously in the dark as to every thing pertaining to the Tichborne family beyond a few stray facts which he had picked up from the newspapers—he did not know where the family property was situated, nor even his mother's name. It is said that at first he was hardly serious about his pretensions, but he was soon surrounded by plenty of those that were serious—attorneys, money-lenders, speculators, hangers-on of all kinds, stupid dupes and conscious accomplices, who backed him up, and urged him on in the enterprise of reclaiming the estate. Moreover, money was needed, and had to be advanced; and those who contributed it, although they may have doubted at first, doubted no longer.

Of course it will be said, a mother would know her own son, and the question of identification could be at once and very effectually settled. But she did not wait to see him before deciding the point. "As she had made up her mind, not only that her son lived, but also that he had lived for a long period among the scum of the human race, under false names and disguises, pursuing low occupations, and willfully forgetting all he was or had ever learned, her anticipations were only corroborated, and her faith strengthened by all she now heard of the man's figure, habits, language, writing, and associations." Every thing was encouraging, and seven years ago the claimant landed in England, and was at once recognized by the overjoyed mother as her long-lost son. The favoring circumstances and the tactics to which they gave rise are thus described by the *Times* writer:

"There was the infatuated mother, who at once handed over to her supposed son every letter, journal, and token of every kind, and all the information she could give toward the establishment—that is, the fabrication—of an identity. The claimant had also clever, and, of course, unscrupulous assistants, who saw at once what they had to do, and who did it. As the appearances were against him, they must not throw away a chance. What they had to do was to construct, by positive and particular evidence of the most minute and circumstantial kind, a fabric of identification so large that even if a good deal were knocked over, there would remain enough for the purpose, or, if not, enough at least to protract the war. Accordingly, all sorts of people were carefully hunted up, sounded as to their knowledge of the true Roger Tichborne, and their own recollections wound out of them. They were then plied with the evidence of others, and put upon the line of inquiry they were to take with the claimant. We think it may be said that every interview, not to say every meeting, of an apparently casual cast, was prearranged, and done by programme. Everybody was frankly told he would be rather startled at first, but at the same time assured that the most competent witnesses had begun with incredulity and ended in full belief. There was a manufactory of affidavits ready to be submitted for the signature of all who had made even a partial surrender of their judgment. The man himself, it was always admitted, was indeed a prodigious development, so the comparison was always led away from the person to some minute or out-of-the-way circumstances, which it was said 'none but Roger Tichborne could possibly have known.' Few considered how completely the defenses had been opened to the claimant, and that he had the run of the Tichborne annals, archives, gossip, and every thing. Every day he had opportunities of acquiring a little more of the social gloss which befitted his assumed rank; every day his stock of information was added to; every fresh witness contributed some items; every day of both trials supplied new materials; every time a question was repeated, the claimant could answer it better than before, being better informed and better advised. Then he could always plead the tricks of memory, and was neither ashamed to have things brought to his remembrance nor to have forgotten what he had said the day before."

Of the stupendous trial which followed, the whole world is aware. Six years ago the claimant applied to the Court of Chancery as a first step to legal proceedings, and three years since he commenced a trial of ejectment in the court of Common Pleas, which lasted six months. Nine months ago he was himself put upon his trial for perjuries committed in the former case, and after 188 days' adjudication he was convicted by the jury in half an hour, as a perjured impostor. The solicitor-general occupied thirty-one days in opening the case, the counsel for defense consumed forty-seven days in summing up, and the chief-justice took eighteen days to deliver his charge, which would have filled 180 columns of the London *Times*. Half a million dollars were contributed by the English people, in the shape of bonds, to enable the claimant to prosecute the case, and, according to the *Spectator*, it cost to all parties—the crown, the Tichborne family, and the defendant's supporters—more than a million and a quarter of dollars!

Such are the leading features of the most extraordinary and the most celebrated lawsuit in all history, which has just come to an end. The question now arises how it became possible to get up so tremendous a struggle over so simple an issue. It might perplex us, far away as we are, to find a satisfactory answer, but the whole British press comes to our relief with a unanimity and an emphasis that are quite remarkable. They agree that the cause of so monstrous and overgrown a procedure is not to be ascribed to the defects of English law-practice, but to the gross ignorance, the silly love of the marvelous, the stupid credulity, and the wide-mouthed gullibility of the English people, who backed up the case and furnished the means for fighting it. The *Spectator* says: "The credulity which has been disclosed throughout the case is positively frightful. . . . Evidence of the most unanswerable character left the believers absolutely unmoved." And of the judge's charge it says: "Nothing but that slow-dripping, luminous narrative, with all its lengthy letters, and all its moral reflections, and all its apt quotations to justify its actions, would ever have fairly driven its illusions out of the British public." The *Saturday Review* says:

"Bishop Butler is reported to have once turned upon his secretary with the alarming inquiry, 'Why might not large bodies of men, and whole communities, be seized with fits of insanity as well as individuals?' The startled secretary could only suggest reliance upon Providence to avert such a calamity. It would certainly appear, however, that there are epidemics, if not of insanity, at least of infectious folly and unreasonableness, which come to pretty much the same thing. It is scarcely possible to account in any other way for such a deplorable exhibition of human silliness as has been afforded in connection with the Tichborne case. The really amazing thing about this imposture, as we look back on it, is, that it should ever have imposed on anybody. . . . An elastic credulity, however, can swallow any thing, and the very difficulties of the claimant's case seemed only to strengthen the blind faith of his adherents. . . . It may be said that stupidity is a misfortune and not a fault; but there is a sort of cranky, cantankerous, pragmatical stupidity which sets itself up as superior to all plain and obvious considerations, and claims the gift of seeing through stone-walls, and of proving that two and two make four only for common folk, which is really an offense against decency and reason. There are people of this kind, who can bring themselves to believe any thing; and Arthur Orton may take his place by the side of the Cock-Lane ghost, the sea-serpent, and Mrs. Toft's litter of rabbits."

The London *Times*, referring to the dupes who were made witnesses, remarks:

"If they fell into an open trap, half England showed themselves ready to do the same. We are all now persuaded that the claimant is a low-born, illiterate, vulgar scoundrel, without any trace of education, either of schools or of society, with no lingering suggestion of culture of any kind about him. . . . It would have been quite impossible for this man Orton to have kept up his enterprise for a fortnight, if his way had not been made easy by a number of dupes of various ranks, which for weeks, and months, and even years, went on increasing. . . . We may now ask—and that is the point which most concerns us—how came this man, in spite of the most unfavorable appearances, to attract, to confirm, and to organize into a sort of faith, so vast an amount of human credulity? The answer must be that, in the first place, a large part of mankind, and that by no means of the lowest or least educated, wish to believe the improbable and prodigious. They are ready for any thing, because they really desire it. For this purpose, and in order that they may be more free to believe what they choose, they close their eyes to the most important and most material facts of the question, and their reasons to the great laws which should control a decision. They prefer to look about for the smaller particulars, the incidental circumstances, and some trifle or other, which may give them a key to the question. Vanity is satisfied, labor saved, and perplexity avoided, by an intuitive assent, resting upon something which, if not wholly inexplicable to other inquirers, is next to nothing at all in the scale of right reason. When people have no laws of judgment in themselves, little experience, or at least little fruit of it, no tests which they know how to apply, their faith, and with it their adhesion, is as much at the mercy of any one who practises upon it as a salmon is at the mercy of a dexterous angler. . . . It has been freely said, and will probably be often said again, that the length of time consumed before Arthur Orton has been convicted, as a perjured impostor, is a scandal upon our law. We cannot join in this opinion. Scandal there has been, undoubtedly, but the blame is misplaced when it is attributed to the administration of justice. The real ground of humiliation is the defect of common-sense, and the imperfect education of so large a proportion of the English people. If one thing more than another is and ought to be the object of training in schools, in colleges, and in daily life, it should be to enable a man of full years, and in the possession of ordinary faculties, to know what to believe, and what to disbelieve, to discriminate the value and the weight of evidence, to reject the false and to detect the true."

The British press, it is evident, has not failed to draw the proper lesson from this seven years' experiment upon the state of mind of that country. It is especially noteworthy that the folly which made it possible was not confined to the illiterate classes; the delusion carried away half the English people of all grades, and the result is no doubt correctly attributed to that general deficiency in educational methods which neglects the proper study of evidence.

And from this point of view the Tichborne case is not without interest to us; for we have an education similar to the English in that it does not enforce the critical study of proof, and therefore leaves the people without protection against the tactics of ingenious imposture. That impositions of all kinds should arise under such circumstances is natural. We may not be able to exhibit any such stunning example of audacious imposture as our English friends have just exploited, but we have plenty of the same kind of thing on a smaller scale. Whether deception and fraud are more extensive here than elsewhere, or more extensive now than formerly, we do not inquire; but their extent is certainly alarming. It would almost seem that overreaching, and circumventing, and the attainment of ends by false pretenses, are becoming organized in our blood, for "smartness" and "sharpness" have acquired new meanings and are openly commended, and nothing is more common than the remark that a little humbug is indispensable in all successful management. Certain it is that we are duped and cheated continually, and in a thousand ways. At home and on the street, in the cars, at public assemblies, and in all the relations of life, we are beset and imposed upon by designing knaves of every shade. We eat the falsified foods of the grocer, and wear the swindling textures of the dry-goods man. We are "done" by unscrupulous shoemakers, and "sold" by dishonest hatters, while builders construct for us fraudulent houses, and upholsterers fill them with sham furniture. The gasmen and the street-cleaners sell us one thing and furnish another, and, turn where we will, we are plied with plausible deceptions, and made the victims of ingenious rascality. Granting that much of this is inevitable, it is certain that more of it might be avoided, and is due to that credulous state of mind by which, like fools, we believe half that is told us.

If, leaving the sphere of private dealings, we take a wider outlook, the case is far from being mended. Under our republican institutions politics is a universal interest and a semi-occupation of everybody, and who does not know that it is given over to interminable deception and the rankest fraud? An unscrupulous demagogism overshadows the land and shoots down its multitudinous roots into the same stupid public credulity. What else are our political parties but contrivances for massing, organizing, and manipulating, the gullibility of the people? Year after year they are fooled by crafty intriguers, and no braying in the legislative mortar is sufficient to drive their foolishness out. The patriotic perfection of the partisan is measured by his swallow; he must gulp every thing that is administered from his own side, and his steady and stupid faith is the stock-in-trade of political gamesters. A motley crowd of those who have outdone their rivals in the unscrupulous tactics of the canvass get together in some grand edifice, which from corner-stone to liberty-cap is a monument of fraudulent jobbing, and they then call themselves a "government," while the superstitious multitude hails the conclave as the "assembled wisdom." Wise in all the arts by which a credulous people are deluded they certainly are; for how else would their lying promises continue to pass from hand to hand as veritable money?

Now, against all this multifarious imposture, this liability to be misled by calculating knaves of every complexion, what is our defense? How much is accomplished by the 300 colleges, and 800 academies, and altogether some 2,000 high-schools, supplemented by 168,000 common schools, in the way of guarding the people against the delusions and deceptions to which they are perpetually exposed? The common schools bring the mass of them up to the point of reading the newspapers, and thus greatly increase their exposure, but they furnish no mental resources of counteraction. The newspaper has its useful office, but it is the most efficient instrument of a vicious partisanship, and an instrument easily wielded by designing men. The higher institutions turn out the raw material which is quickly worked up into knavish managers on the one hand, and credulous partisan gulls on the other; for, as Mr. Carlyle remarks, "quack and dupe are at bottom the same thing." We find the cause of this wide-spread evil, as the *Times* remarks, in a faulty mental training which gives the cultivated man but little advantage over the illiterate one. It is questionable, indeed, if the common sense of untaught people is not to-day quite as good a defense against preposterous pretensions, and the arts of skillful deception, as the elaborate cultivation of the schools. It is true that logic, as the art and analysis of reasoning, is more or less taught, but it is taught to but little practical purpose. Learning the rules of logic may assist to make a dexterous intellectual fencer, but it will no more make a circumspect and cautious thinker than learning the rules of morality will make a virtuous man. The darkest period of human credulity, when no extravagance was too gross to be greedily swallowed, was the golden era of the study of logic in all the schools of Europe.

It is often said that we are indebted to modern science for the emancipation of the human mind, but it is frequently forgotten in what its slavery consisted, and how science proceeded to set it free. The mental thraldom of the dark ages consisted in the submission of the mind to beliefs imposed on it by authority, and interpreted by authority; the effect of which was to make blind credence the universal mental habit. The influence of theology was by no means confined to religious opinions. Men accepted their views of Nature on the authority of Aristotle as much as their creeds on the authority of the Fathers. Holding it sinful to disbelieve, they avoided the sin in all things. Modern Science began by attacking this state of mind, and has won her great conquests on the principle of the supremacy of personal observation as against the weight of traditional belief. But there must be doubt of authority before there can be rebellion against it. The first step toward truth, or the verification of opinions, is therefore a skeptical state of mind in regard to what has hitherto passed as truth. The great poet missed the philosophy of the case when he said:

> "Truth can never be confirmed enough,
> Though doubts did ever sleep;"

for the slumber of doubt is not favorable to the confirmation of truth. There is but one thing that can protect people against the thousand-fold insidious and plausible impostures to which they are continually and everywhere exposed, and that is a resolute mood of skepticism, and an intelligent habit of sifting evidence that shall become a daily and constant practice. Our education is here seriously at fault. It neither provides for the requisite discipline, nor does it insist upon its necessity. The old universities were originally religious seminaries, and all teaching was at first in the hands of the clerical profession; while even yet our presidents of colleges are mainly doctors of divinity. The world owes much to the clergy as the conservators of learning in the past, and the teachers of mankind when there were no others to perform the office; but their service in this respect has not been an unmingled good: it has had its drawbacks which still survive. To this day there is an almost universal feeling that belief and disbelief answer to each other as virtue and vice. The very terms which indicate the state of mind preparatory to all rigorous investigation of truth are tainted with prejudice and held to involve an implication of criminality. With such a bias it is most difficult to train the mind to that healthy habit of doubt which shall give it protection against the thousand-fold impostures which assail it on every side.

Perhaps the evil here considered can never be wholly eradicated from society, but much can be done to diminish it, and it is the proper office of education to do it. And as science by its mental method has put an end to the grosser forms of credulous belief and blind superstition, so when that method is carried into general education we may expect still further advantages of the same kind. Scientific education, truly such—not the mere committal and recitation of text-books, but a practical and systematic exercise of the mind in observation, inference, judgment, and the weighing of evidence—will meet the present requirement as nothing else can. Much may be done by the diffusion of scientific knowledge to dispel the ignorance which is taken advantage of by practised charlatans; but people cannot learn every thing, and there are many things of which the most intelligent must remain ignorant. There ought, however, to be no difficulty in learning how to deal with the claims and pretensions that are put forward, even though the facts involved are not understood; and this is simply a question of the criteria of truth and of cautious habits in accepting proof.

THE PROGRESS OF THEOLOGY.

In our office as chroniclers of the progress of scientific thought, we are called upon to record some further and marked concessions to the position that the doctrine of Evolution is not an anti-religious doctrine. For the last fifteen or twenty years since this theory has been definitely enunciated, and sustained on scientific grounds, there has been vehement protest, on the part of many theologians, that it negatives all possibility of religion. The leaders have not hesitated to make up the issue between religious belief and a doctrine of science which simply depends upon accumulated evidence. The view supposed to be so fraught with danger has, however, been steadily making its way in the minds of those most competent to judge of its truth; and now it is beginning to be perceived that the alarm was groundless, and that, though Evolution be established, the great questions of theology remain just where they were before. A favorite position has been that the conception of Evolution is inconsistent with the idea of Divine design in Nature, but it is now acknowledged that the only effect is to substitute a larger for a narrower view of design. Dr. McCosh, in his lectures, a year or two since, put the question on this broad ground. He said, virtually, "Establish whatever facts you please in regard to the workings of Nature and the order of the universe, and behind the whole phenomenal scheme I find the Infinite mind by which it was all designed." A new and very able work has just appeared, entitled "Darwinism and Design; or, Creation by Evolution," by Mr. George St. Clair, F. G. S., in which the whole problem is elaborately discussed from the new point of view. The author takes the same ground as Dr. McCosh, and argues ably against those who hold that Evolution is destructive of teleology, or the doctrine of ends and purposes in Nature. He admits that it is inconsistent with the old restricted interpretations of teleology, but claims that it only substitutes a far more comprehensive principle of the same kind. We note that the *Nonconformist*, the organ of the English Dissenters, and one of the stanchest orthodox periodicals, gives in its adhesion to Mr. St. Clair's positions, and highly commends his work. An article in our present number gives the argument upon this subject of Prof. Jevons, the able English logician, to the same purport, and also the substance of an address by a distinguished divine of New York, illustrating similar views. The present aspect of the case thus becomes interesting. It looks as if theology itself were about to take a great advancing step, which it has stoutly resisted, but has been at length compelled to take by the advance of scientific research. After a few more such experiences it is to be hoped that our friends will begin to recognize that theology is also progressive, and that, so far from being an enemy, Science is a helping friend of true religion.

LITERARY NOTICES.

Principles of Mental Physiology: With their Applications to the Training and Discipline of the Mind, and the Study of its Morbid Conditions. By William B. Carpenter, M. D., LL. D. New York: D. Appleton & Co. 737 pages. Price, $3.00.

As this work was announced to appear in the "International Scientific Series," and has been withdrawn from it, a word of explanation is here desirable. In drawing up the plan of this series, it was decided that one of the books now most called for is a compendious treatise upon the science of man, based upon the intimate interactions of body and mind, or what may be termed Mental Physiology. While Prof. Bain took up the theories of their relation as a philosophical question, there was wanted a practical exposition of the science of Human Nature, such as might become a text-book of guidance and education in the general conduct of life. Dr. Carpenter, whose numerous and well-known physiological works covered this ground more perfectly than those of any other author, was applied to as the most competent man to prepare the work required. When solicited to undertake it, although much occupied with his active duties as Registrar of the London University, and absorbed in a course of special scientific inquiries, he cordially consented, and at once entered upon the labor. But it soon became apparent that the subject was too large to be compressed within the limits which were thought advisable for such a series, and, rather than impair the value of so important a work, it was found best to take it from the list and issue it separately. It conforms, however, to the popular style of these works, and is well adapted for general reading.

Dr. Carpenter's work is neither a technical treatise upon physiology nor a manual of scientific psychology, but it is an elaborate exposition of those relations of body and mind which must form a foundation of any true science of human nature. Physiology is generally considered as a science that belongs to the doctors, and of which it is necessary for everybody to know something for hygienic reasons. But the study of man, for general practical purposes, has hitherto been held to consist in the study of mind, while that has been considered from the metaphysical point of view, the body being thrown out of the account. This has been the powerful tendency of the past, and it is still so influential that books upon the so-called science of man are still frequently issued which are limited to one portion of his nature, and that, too, studied by a false method and out of all its actual relations. This disruption of man and the contemptuous dismissal of one part of his being as his "lower nature," while the other is magnified and dealt with apart, has been formerly defended on religious grounds; and the attempt to bring his whole nature into view and to consider it in its wonderful unity has been resisted as involving "materialism." This view is, however, latterly giving way, and it is more and more recognized that man must be studied in the totality and living harmony of his nature. Dr. Carpenter quotes the impressive words of Charles Buxton in his "Notes of Thought," as indicating the point of view that must now be taken in relation to this subject. Mr. Buxton says: "Irresistible, undeniable facts demonstrate that man is not a den wherein two enemies are chained together, but *one being*—that soul and body are one—one and indivisible. We had better face this great fact. 'Tis no good to blink it. Our knowledge of physiology has come to a point where the old idea of man's constitution must be thrown aside. To struggle against the overwhelming force of science under the notion of shielding religion is mere folly."

Dr. Carpenter adds: "These well-considered conclusions of a deeply religious mind may be specially commended to the consideration of those who are disposed to condemn without examination any thing that savors of 'materialism' which they have been accustomed to regard as philosophically absurd and morally detestable. And those who assume that physiological psychology strikes at the root of morals and religion may be fearlessly asked to show in what a system which leaves the will of man free to make the best use he can of the intellectual and moral capacities with which his bodily organism has been endowed by his Creator, and which gives him the strongest and noblest motives, both for self-discipline and for philanthropic exertion, is unworthy of the nature and destiny of the being whose creation in the 'image of God' can have no higher meaning than his capacity for *infinite progress*."

The difference between the new point of view and the old is not a mere speculative difference, or a matter of abstract belief. The study of man as an actual whole, a complex working phenomenon, and a fact of experience, has given us a kind of knowledge that is invaluable for the uses of all in every-day life. This kind of knowledge, concerning human nature, has been long and slowly accumulating, as the result of modern observation, though it has recently become more extended and accurate in many particulars, and Dr. Carpenter's work, we may say, has first presented it with the systematic fullness which its importance demands.

In his plan of treatment, Dr. Carpenter classifies from the mental side; that is, it is mental phenomena and problems that are successively taken up. After a preliminary statement of the general relations between mind and body, in the first chapter, he takes up the structure and modes of action of the nervous apparatus in the second chapter, and then proceeds to consider in successive chapters the subjects of Attention, Sensation, Perception, and Instinct, the Emotions, the Will, Memory, Common-sense, Unconscious Cerebration, Reverie, Sleep, Dreaming, Somnambulism, Electro-biology, Mesmerism, and Spiritualism, Intoxication and Delirium. But each and all of these manifestations are considered, not in themselves merely, but as conditioned by the physiological constitution. Whatever may be their ultimate nature, practically they are effects of a vital mechanism by the laws of which they are determined. Much of this wonderful connection is of course, as yet, far from being understood. We are indebted to Dr. Carpenter for having shown that a great deal more is understood of the psychical and vital interactions than has become generally known. Dr. Carpenter has won his reputation as a physiologist, largely from the clearness of his expositions, and the present work shows that his capacity in this respect is still vigorous. Its most scientific parts are attractive reading, and the extensive array of personal instances and incidents, which illustrate his positions, gives great fascination to the volume. It is a book hard to lay down when once entered upon, and Dr. Carpenter may be congratulated upon having contributed so fresh and adequate a book upon such an important subject.

THE PRINCIPLES OF SCIENCE. A Treatise on Logic and Scientific Method. By W. STANLEY JEVONS, M. A., F. R. S., Fellow of University College, London; Professor of Logic and Political Economy in the Owens College, Manchester. New York: Macmillan & Co. 2 vols., 943 pages. Price, $9.

THIS able treatise is entitled to be classed at once with such valuable and solid works as Mill's "Logic," Whewell's "History of the Inductive Sciences," and Herbert Spencer's "First Principles." Whether it be equal to either of those treatises, as a contribution to scientific knowledge, we shall not assume to say, but it is certainly a timely and powerful exposition of scientific method, in the light of the later advances of knowledge. The author sets out with the assumption, which few will question, that the rapid progress of the physical sciences during the last three centuries has not been accompanied by a corresponding advance in the theory of reasoning. Physicists are usually too much engrossed in the immense and ever-accumulating details of their special sciences to give sufficient attention to the methods of reasoning which they unconsciously employ. It becomes necessary, then, that certain minds should devote themselves absorbingly to this neglected side of science, for few will deny that the clearing up of questions of order, logic, and method, are indispensable to its rational progress. To do any justice to this work, by a notice or review of it within such space as we can allow, would be impossible, and the best course is to let the author speak for himself in regard to the aims and characteristics of his undertaking. The following passages are from his preface:

"The study both of Formal Logic and of the Theory of Probabilities has led me to adopt the opinion that there is no such thing as a distinct method of induction as contrasted with deduction, but that induction is simply an inverse employment of deduction. Within the last century a reaction has been setting in against the purely empirical procedure of Francis Bacon, and physicists have learned to advocate the use of hypotheses. I take the extreme view of holding that Francis Bacon, although he correctly insisted upon constant reference to experience, had no correct notions as to the logical method by which, from particular facts, we educe laws of Nature. I endeavor to show that hypothetical anticipation of Nature is an essential part of inductive inquiry, and that it is the Newtonian method of deductive reasoning, combined with elaborate experimental verification, which has led to all the great triumphs of scientific research.

"In attempting to give an explanation of this view of scientific method, I have first to show that the sciences of number and quantity repose upon and spring from the simpler and more general science of logic. The theory of probability, which enables us to estimate and calculate quantities of knowledge, is then described, and especial attention is drawn to the inverse method of probabilities, which involves, as I conceive, the true principle of inductive procedure. No inductive conclusions are more than probable, and I adopt the opinion that the theory of probability is an essential part of logical method, so that the logical value of every inductive result must be determined consciously or unconsciously, according to the principles of the inverse method of probability.

"The phenomena of Nature are commonly manifested in quantities of time, space, force, energy, etc.; and the observation, measurement, and analysis of the various quantitative conditions or results involved, even in a simple experiment, demand much employment of systematic procedure. I devote a book, therefore, to a simple and general description of the devices by which exact measurement is effected, errors eliminated, a probable mean result obtained, and the probable error of that mean ascertained. I then proceed to the principal, and probably the most interesting, subject of the book, illustrating successively the conditions and precautions requisite for accurate observation, for successful experiment, and for the sure detection of the quantitative laws of Nature. As it is impossible to comprehend aright the value of quantitative laws without constantly bearing in mind the degree of quantitative approximation to the truth probably attained, I have devoted a special chapter to the theory of approximation, and, however imperfectly I may have treated this subject, I must look upon it as a very essential part of a work on scientific method.

"It then remains to illustrate the sound use of hypothesis, to distinguish between the portions of knowledge which we owe to empirical observation, to accidental discovery, or to scientific prediction. Interesting questions arise concerning the accordance of quantitative theories and experiments, and I point out how the successive verification of an hypothesis by distinct methods of experiment yields conclusions approximating to but never attaining certainty. Additional illustrations of the general procedure of inductive investigations are given in a chapter on the 'Character of the Experimentalist,' in which I endeavor to show, moreover, that the inverse use of deduction was really the logical method of such great masters of experimental inquiry as Newton, Huyghens, and Faraday.

"The application of scientific method cannot be restricted to the sphere of lifeless objects. We must sooner or later have strict sciences of those Mental and Social phenomena which, if comparison be possible, are of more interest to us than purely material phenomena. But it is the proper course of reasoning to proceed from the known to the unknown—from the evident to the obscure—from the material and palpable to the subtile and refined. The physical sciences may therefore be properly made the practice-ground of the reasoning powers, because they furnish us with a great body of precise and successful investigations."

It is thus evident that the plan of Prof. Jevons's work involves a thorough handling of the most recent questions that have been raised in science and philosophy, and an examination of it will show that he has carried out his project in an able and independent manner. We publish a portion of his last chapter, showing his liberality of view. It is to be hoped that the publishers will find it for their interest to modify the price of this work, so as to bring it within reach of a large circle of those who, in our opinion, would be glad to have it.

Politics and Mysteries of Life Insurance. By Elizur Wright. Boston: Lee & Shepard. 238 pp., 12mo. Price, $1.50.

The object of this work is to call public attention to certain practices in the existing system of life insurance, entailing loss and injury upon the policy-holder. Chief among these practices is the treatment of holders who allow their policies to lapse by non-payment of the premium, or surrender them from a desire to change the investment. In either case it is usual for the company to issue a "paid-up policy," that is, a guarantee to pay a fraction of the original policy at the expiration of its term, or to pay the resigning policy-holder a small sum of money as the "surrender value" of the policy. Mr. Wright assumes, and it must be confessed with great show of reason, that the "surrender value," in all cases where the policy has existed beyond three years, and in some cases beyond one year, is far less than the amount the policy-holder is justly entitled to receive. According to his idea, legitimate life insurance is a compound of insurance proper with the savings-bank business, and his system is therefore termed Savings-Bank Life Insurance. From this point of view all premiums paid are resolvable into two parts. One part pays the cost of insurance, that is, the expenses of the company: the other is merely a deposit, in trust with the company, for gradual accumulation to equal the sum of the policy by the time that that shall become due. Either part may be larger or smaller, according to the nature of the policy. With "ordinary life" policies, the premiums are small, and distributed over a great number of years; there is, therefore, great risk that the company will have to pay the policy before the accumulated deposits can yield a sum to equal it. To compensate it for this great risk, the company is justified in taking for itself the largest part of the premium. But, in the case of an endowment policy of short term, the premium being large and confined within a few years, the deposit accumulates very rapidly, and will soon equal the policy. There being, therefore, much less risk than in the former case, the company can be justified in taking only a small part of the premium for its own use. Thus it is plain that the company's share of the premium is largest in the case of an ordinary life policy, and smallest in that of a short-term endowment policy. It is called the "insurance value," and is appropriated to the payment of the expenses of the company. The policy-holder's share of the premium is smallest with the first kind of policy and largest with the last; it is called the "reserve," and should never be touched for any other purpose than the payment of the policy to which it belongs. Mr. Wright contends that the policy-holder should be at liberty to return his policy at any time, and withdraw the "reserve" unimpaired, save in a small sum to compensate the company for the loss of a good risk. In some cases the policy-holder is entitled to recover more than the "reserve" when he surrenders his policy. This occurs with "single-premium policies"—policies on which many future small premiums are anticipated, or commuted by the payment of a single large premium. This single large premium, like the small annual premiums considered above, resolves into two parts, the "insurance value" and the "reserve." The "reserve" is the same in nature as with the annual premium, though of course much larger; but a new element enters into the composition of the "insurance value." The "insurance value" of an annual premium compensates the company for its risk in one year, while the "insurance value" of a "single premium" compensates the company for its risk during all the years that the policy has to run. Now, if the holder of a "single-premium policy," having twenty or more years to run, becomes desirous to surrender his policy at the end of five years, he should get back from the company, not only the "reserve," but also that portion of the "insurance value" that has been set apart by the company to compensate for the risk attached to the remaining fifteen or more years of the policy's term.

Clearly, if the company retains more of the "insurance value" than will compensate it for bearing the risk during the five years that have expired, it will exact pay for work that it has not performed, and its proceeding cannot be justified on any ground of equity. The company is, of course, entitled to some compensation for the loss of its interest in the "insurance value" that it would have earned had the policy remained in force; but it is idle, as well as inequitable, to contend that the compensation should equal the "insurance value." It seems to us that the present value of the unearned "insurance value" would be the just compensation. Mr. Wright, however, argues that it should be only enough to enable the company to procure as good a risk as the one it has lost by the surrender of the policy, and that eight per cent. of the unearned "insurance value" would be sufficient for this purpose; that is, eight per cent. would yield an amount equal to the commission usually paid to an agent to obtain a risk. Mr. Wright, it is seen, holds that loss of the risk is that for which the company should be compensated, but to us it seems to be, as above expressed, loss of interest in the "insurance value" which would have been paid to it had the policy remained in force. This "insurance value" on the company's share of the premiums is supposed to compensate the company for the risk of undertaking to carry the policy, and is clearly the only interest that the company has in the transaction. The compensation that the company receives in case of surrender is called the "insurance charge." As it is based on the "insurance value" it varies proportionately, and is therefore largest on "ordinary life policies" and smallest on "short-term endowments," and on the latter class of policies it decreases as the age of the policy increases. To recapitulate, Mr. Wright contends that life insurance is compounded of insurance proper and the business of the savings-bank; that the premiums consist of two parts, the "insurance value," which belongs to the company when earned, and the "reserve," which belongs to the policy-holder, having been merely deposited with the company for accumulation, to be withdrawn whenever it suits him to return his policy; that the company for its interest in the risk is entitled to make a "surrender charge" when the policy is returned; and that this "surrender charge" should be based on the "insurance value," but should constitute only a very small part of it. This is, without doubt, a just conception of the nature of life insurance; but, while the companies agree with Mr. Wright in dividing the premiums into "insurance value" and "reserve," they disagree with him as to the ownership of the "reserve," half of which they insist on retaining for themselves, in case of surrender. The Mutual Life, of New York, retains from fifty to seventy-five per cent. of the "reserve," in settling for surrendered policies, and the Equitable from fifty to sixty per cent., and this is done on all policies alike, without respect to age or class. Having just seen that the "surrender value," usually constituting the difference between the "reserve" and a moderate "surrender charge," and sometimes exceeding the "reserve," varies in amount with the class of the policy, and far more so with its age, the reader is competent to decide for himself whether the company's uniform practice of retaining from fifty to seventy-five per cent. of the "reserve" on all policies is or is not equitable. For our part we think, with Mr. Wright, that it is not.

Mr. Wright further contends that both the "surrender charge" and the "surrender value," at any period of the policy's existence, should be ascertained sums, and known to the policy-holder before he insures, so that he can understand all the terms of the contract he is making. For this purpose he has prepared, and inserted in the book, several specimen-tables showing the "insurance value," the "reserve," the "surrender charge," and the "surrender value" of various classes of policies at the time of issue and in each year thereafter. This is precisely what the companies claim cannot be done. They say that the "surrender value" at any future time cannot be calculated, because it is impossible to foretell what the dividends or surplus above working cost will be. But, throwing dividends out of the question as an unessential factor, the thing becomes easy enough. For instance, no company will deny that the "reserve" at any period of the policy's existence can be easily ascertained. But the "reserve" is made up of one part of the premiums, and, if this part can be ascertained, why cannot the "insurance value," which is made up of the other part of the premiums, be also ascertained? It is unnecessary to know any other factors than these, to be able to determine the amount of the "surrender value." The latter factor forms the basis of the "surrender charge," which may be eight per cent. of it, and the "surrender charge" deducted from the former leaves the "surrender value."

We have thus endeavored to give a brief outline of the main feature of Mr. Wright's book; the others are chiefly incidental to the illustration of this one. The glimpses occasionally given of the manner in which matters are conducted beneath the surface of life insurance are not calculated to leave on the reader's mind a favorable impression of at least one or two of the actors. In this connection, however, the tone of the writer is not always as dignified as it might be. The chapter at the end of the book, on the relation between currency and life insurance, exhibits some sound financial views. The book aims a vigorous blow in defense of the people, and it is to be hoped that its effect will be decisive.

Contributions to Solar Physics. By J. Norman Lockyer, F. R. S. New York: Macmillan & Co. 1874. 676 pages. Price, $10.

The avidity of the general public for information in regard to recent researches in physics, and particularly in regard to researches made by aid of the spectroscope, is witnessed by the number of volumes which have appeared within the past few years devoted solely to the popular exposition of these subjects. The announcement of a new book with the same purpose is one which, we should fancy, the average reader of these books would receive with mingled feelings. It seems to us that this average reader, while feeling that it was his duty to rejoice that the class which he represents was being so very fully supplied with treatises on a certain class of topics, would likewise begin to doubt whether the topics themselves had not been exhausted.

At least, he might doubt whether the popular exposition of them had not been carried to an extreme point. Certainly it seems very hard to add to the books of Roscoe and Schellen any thing in regard to the fundamentals of Spectrum Analysis, which shall be worth adding. It is easy to conceive our average reader turning the pages of a new book of this sort with a kind of nervous fear, lest he should come across those tiresome wood-cuts of a German-looking man gazing intently into a prism in the hope of seeing a candle-flame double, or of two sombre individuals shut up in a dark and very large room, alone with Newton's experiment. These wood-cuts he has seen for years, and they seem to him as the brown-stone houses on the Fifth Avenue seem to the weary traveler; mile-stones that he can never pass—"a procession which never gets past its given point."

Now, we distinctly sympathize with our average reader, and we claim that a book of this nature, to be necessary or even acceptable at this time, must be a decided step in advance of the former ones.

The volume before us contains 676 pages (including a good Index), and it is divided into two parts: Part I. is devoted to a popular account of ancient and modern Sun-work; Part II. contains communications made by the author to the Royal Society of London, and to the French Academy of Sciences. Added to these we have sixteen valuable Notes on various special points; and two Appendices, one giving the "Instructions to Observers of the Eclipse of 1871," and the other being Respighi's "Memoir on Solar Prominences."

To consider the volume in inverse order, we may say that, of Part II., the valuable Notes and Appendices are the only parts which ought to have been given in their present form, according to our judgment, and it may even be doubted whether the Notes should not have been worked into the text. Mr. Lockyer says, in regard to the contributions to the Royal Society and to the Academy of Sciences, that they are "of course" given *verbatim*. Here the author has, it seems to us, forgotten the proper object of his book. These papers were written from time to time as results began to come from the "new method," and they are of necessity incomplete. The only object in giving them in their original form is to show exactly Mr. Lockyer's relation to the progress of discovery and research. But the history of the subject is very well known among all interested in it, and Mr. Lockyer's foremost place in certain branches of it is too well established to need a repetition of the formal proofs.

To the scientific worker these papers are already accessible in the original, and, for general purposes, they should have been entirely recast, as they are decidedly not in the best form now.

With regard to the first part of the work we may say that much of it is a repetition of matter which has been thoroughly treated in other books. Some of it consists of accounts of eclipse-work which the author himself did, and the story of this is told in a thoroughly good and interesting way. Mr. Lockyer's accounts of the work of others are eminently fair, and exhibit good feeling and entire appreciation. The chapter on Mr. Carrington's researches on solar spots is an example, and the author's account of the discovery of the new method of viewing prominences which was applied by Janssen and himself, though first conceived by Lockyer, is thoroughly admirable for fairness and candor.

Part I., however, has more serious defects than the final section of the book. It is entirely deficient in judicious arrangement, and its perusal can only confuse the ideas of the learner. It is, in fact, a reprint of essays (each of them good in itself and in its place), which Mr. Lockyer, sometimes alone, sometimes in concert with Mr. Balfour Stewart, contributed to English periodicals, and of occasional lectures.

It abounds in repetitions; sometimes whole paragraphs, almost pages, are printed at least twice, and the whole seems to show a desire, to speak plainly, to "make a book."

We must insist that, while it is, abstractly, a thing to be grateful for that Mr. Lockyer should give his valuable time to the popular exposition of scientific truths, some of which he has been so fortunate as to discover, it is, in the case before us, still a fact that he has added scarcely any thing to the ample information in regard to them which is now accessible, and nothing at all to his scientific reputation.

His character as a man seems to be shown, in his account of his relation to other scientific men—his friends—and that is almost the only outcome of this expensive volume, whose principal fault is a want of a sufficient *raison d'être.*

The Martyrdom of Man. By Winwood Reade. New York: Asa K. Butts & Co. 543 pp. Price, $3.00.

The reader of this book is long puzzled to discover the fitness of the title to the matter presented for his consideration, nor can he, until, near the end, the author's view is revealed to him, that each generation of mankind, from the conditions of its existence, is subjected to physical persecution —or martyrdom—that the condition of the succeeding generation may be improved. The current theology is repudiated, and with it the idea of the individual existence of the human soul after death. The idea of a God, impersonal, indefinable, and unknowable, is, however, retained and strongly enforced; and with it there seems to be connected in the author's mind, though it is not clearly expressed, an idea that the human soul is immortal in the sense of being a materially embodied part of the great animating power of the universe, into which it lapses—losing its individuality—after the death of the body. To expound these views is really the aim of the book, although it ostensibly purports to be a kind of universal history of human progress, written to show the influence of Africa upon civilization. It is divided into four chapters. The first presents a panoramic portrayal of the ancient civilizations of Egypt and the north of Africa, Asia Minor, Greece, Rome, their rise, maturity, and decay, and the influence they exercised upon each other. The second chapter deals, after the same manner, with mythology, Judaism, Christianity, Mohammedanism. The third traces the progress of Liberty, giving a comparatively extended account of the origin of the slave-trade and the antislavery movement, and their influence upon American affairs.

The last chapter sketches the rise and progress of intellect, and pictures its probable future. The theories of evolution and natural selection form the ground-work of the plan. The author acknowledges his indebtedness to others for his facts, but is entitled to some credit for originality in the conception and arrangement of the work. The style is vigorous, and entices the reader into more than a cursory perusal.

The Structure of Animal Life. By Louis Agassiz. New York: Scribner, Armstrong & Co. 128 pages, 8vo. Price, $1.50.

This book comprises a series of six lectures, delivered in 1862, before the Brooklyn Institute, and first published in 1865, but now reissued, the former editions having passed out of print. The lectures were delivered for the purpose of showing that there is "order in Nature; that the animal kingdom, especially, has been constructed upon a plan which presupposes the existence of an intelligent being as its author," and the "scientific grounds of the working of a Providence in the world." In the last respect, the view advanced is that the present diversity of animal life, or species, has not resulted from the influence of outward circumstances upon a few primarily simple forms, but from the direct and continually-repeated workings of a Divine Will or Providence; in other words, that the diversity has resulted from Divine creations. The arguments adduced to prove this part of the theory are grounded upon the fact that geologic revelations show certain low forms of animal life to have existed in former periods, in greater diversity than at present. The first lecture presents the plan of the animal kingdom as exhibited in its four great divisions; the second presents the relative standing of each division to the other, and of the various members of each division; the third proves the antiquity of animal life by the existence of coral-reefs; the fourth gives an outline of the geological history of the earth. The remaining two lectures are devoted to proving the theory of an intervening Providence. The book is full of interesting facts, and eminently adapted to the theology of the day.

Present Status of Social Science: A Review, Historical and Critical, of the Progress of Thought in Social Philosophy. By Robert S. Hamilton. New York: H. S. Hinton, 744 Broadway. 332 pages. Price, $2.00.

A well-executed book, upon the subject here designated, would be very valuable: the present one seems to be not up to the requirement. Upon a class of questions which, of all others at present agitating the scientific world, are the freshest and the newest, this is an old book. It was prepared for publication seven years ago, and was not even then up to the times. An example of the antiquated and unreliable character of the work is afforded by the author's treatment of the most eminent thinker of the time on problems of social science. Mr. Herbert Spencer is judged as a sociologist by his views developed in "Social Statics;" how fairly will appear from the fact that "Social Statics" was Mr. Spencer's first work, published twenty-four years ago. And not only this, but he was himself so dissatisfied with it that he would not consent to its republication in this country, without incorporating a preface which indicated that his views had undergone important modification. It was, in fact, from the incompleteness of the basis of this discussion for a true sociological science that Mr. Spencer was led to devote himself for twenty years to the development of a system in which the foundations of sociology should be more deeply and securely laid in the sciences of life and mind, and the laws of Nature, in their latest and highest interpretations.

Mr. Hamilton's book ranges wide over the field of social philosophy, and discusses the views of many men in relation to it, but, with much information, there is a vague speculation, and more of criticism than history. Of social science, as a simple generalization of social phenomena, or a body of principles based upon facts of observation, like other sciences, he seems to have but an obscure conception, as is evinced by the following statement of the problems of social philosophy: "What are the causes or laws which determine the social destiny of the individual, which determine in the long-run, and in the absence of extraordinary disturbing causes, whether he shall be prosperous or the contrary; whether he shall be a pauper or millionaire; a laborer or capitalist; a peasant or prince—which determine, in short, whether his own internal momentum or *centrifugal* force shall be overpowered by the potent gravitation, or *centripetal* force, which is constantly prostrating human efforts, or shall enable him to maintain an independent position, and REVOLVE IN AN ORBIT OF HIS OWN."

A TREATISE ON THE METHOD OF GOVERNMENT SURVEYING. By SHOBAL V. CLEVENGER, U. S. Deputy Surveyor. New York: D. Van Nostrand. 200 pp., 12mo.

THE author states that the peculiarities of Government surveying being unexplained by existing works on land-surveying, new contractors with the Government are often embarrassed by the want of information on the subject. To meet this want, the treatise was prepared. The principles of surveying, the application of astronomy, and the uses of instruments and of logarithmic tables, are expounded briefly but intelligibly. Suggestions are also made for procuring a surveying outfit, and for rendering the alkaline waters of the Western Plains fit for drinking. Tables of convergences, logarithms, etc., are given at the end. The book is bound in morocco for pocket-use.

THE BORDERLAND OF SCIENCE. By RICHARD A. PROCTOR, B. A. Philadelphia: J. B. Lippincott & Co. 438 pp., 8vo. Price, $4.00.

THIS is an embodiment in book-form of a series of essays previously published in the *Cornhill Magazine*. The title forcibly indicates the nature of the subjects discussed, these being generally beyond the pale of exact science, yet possessing in some degree a scientific character. However, with regard to the last three essays, "Gambling," "Coincidences," and "Ghosts," it is difficult to recognize their claim to a position under the title, except in the effort of the author to combat, after an analytical or scientific method, the errors prevailing on those subjects. The essay on "The Herschels and the Star-Depths" sketches the observations of those great astronomers on the "dark portions" of the heavens, and their resulting discoveries of nebulæ. "A Voyage to the Sun," and "A Voyage to the Ringed Planet," in the assumed and fanciful form of a journey to those luminaries, describe their features and the peculiar theories relating to each. "Life in Mars" discusses the reasons for believing that some kind of animal life exists upon that plaent, and "A Whewellite Essay on Mars" gives the reasons for doubting that that life resembles such as we see upon our own. Besides several other essays on astronomical subjects is one on "Earthquakes," another on "Coal," and still another on "Flying and Flying-Machines." The clear and vigorous style and varied character of its contents make the book highly interesting. It is to be regretted that it was not published in a cheaper edition.

THE GALVANOMETER AND ITS USES. By C. H. HASKINS. New York: D. Van Nostrand. 76 pp., 12mo

OF suitable size, this book is intended as a pocket manual for students of electricity, as well as a reference-book for experienced electricians. It explains, at the beginning, the laws upon which galvanometric measurements are based, next the galvanometer itself, and lastly the uses of the instrument. It is illustrated throughout. To the end are appended useful tables of the wires and tangents, and of the weights and resistances of iron and copper wires.

MISCELLANY.

Relics of an Ancient Malayan Civilization.—At the November meeting of the California Academy of Sciences, photographs of curious hieroglyphics, cut in wood and found on Easter Island, were received from Mr. Thomas Croft, of Papeeti, Tahiti. In accordance with vague traditions current among the natives, they were supposed to represent the written language of some prehistoric race. The stone idols found on the island exhibit a refined form of art, and other relics found there go to prove that the present population are the degenerate relics of a once powerful nation. In the letter accompanying the hieroglyphics, Mr. Croft stated, from the best information he could obtain, that none except the priests, and a chosen few, could decipher these strange characters. At a recent meeting of the

Academy, another letter from Mr. Croft was read, in which he stated that he had found a native of the island who could read them, and who was going to teach him the language, so that he will shortly be able to translate them. Mr. Croft thinks that he has discovered the relics of a great Malayan empire, which extended its power over that part of the ocean at some former period of the island's history.

Deposits in Steam-Boilers.—Prof. S. Dana Hayes, writing in the *American Chemist* about deposits in boiler-flues, says that they are of two kinds, both of which are capable of corroding the iron rapidly, especially when the boilers are heated and in operation. The most common one consists of soot (nearly pure carbon) saturated with pyroligneous acid, and contains a large proportion of iron if the deposit is an old one, or very little iron if the deposit has been recently formed. The other has a basis of soot and very fine coal-ashes (silicate of alumina) filled with sulphur acids, and containing more or less iron, the quantity depending on the age of the deposit. The pyroligneous deposits are always caused by want of judgment in kindling and managing the fires. The boilers being cold, the fires are generally started with wood; pyroligneous acid then distills over into the tubes, and, collecting with the soot already there, forms the nucleus for the deposit, which soon becomes permanent and more dangerous every time wood is used in the fireplace afterward. The sulphur-acid deposits derive their sulphur from the coal used; but the base, holding the acids, is at first occasioned by cleaning or shaking the grates, soon after adding fresh charges of coal. Fine ashes are thus driven into the flues at the opportune moment for them to become absorbents for the sulphur compounds distilling from the coal, and the corrosion of the iron follows rapidly after the formation of these deposits.

Conditions affecting the Sex of Offspring.—In the *American Naturalist* for January, Dr. John Stockton-Hough has an elaborate article on "The Relationship between Development and the Sexual Condition in Plants." His conclusions are: 1. That in plants, and animals as well, that are actively occupied in vegetative, physiological, pathological, or other efforts which are antagonistic or complementary to the office of reproduction, the proportion of females born during such times is greater than where the plant or animal has reached full developmental maturity and growth, is in good health, and is occupied principally in the process of reproduction. In the latter condition offspring of a higher developmental condition are produced, and the proportion of males is increased. 2. Females are in better condition, more troubled by disease, or other process antagonistic to reproduction, where they conceive with females than with males; and they are poorer, because more exhausted and less healthy, by the production of female offspring, than by male products. 3. It is just possible that the ovules from which females are derived may have a higher initial vitality, though they be less highly developed than those from which males are derived, yet no egg can properly be said to be predestined to be male or female. 4. That female plants, like female animals, are less highly developed than males, and are the result of an inferior developmental reproductive effort on the part of the female parents.

Axial Buds in the Juglans Nigra.—In most plants there is a single bud in the axil of the leaf known as the "axillary bud." In the hickories, walnuts, and some others, there are two or more, one above another, known as supra-axillary buds. When remarking on the sexual characters of the buds of *Juglans nigra*, before the Academy of Natural Sciences of Philadelphia, the specimens I used in illustration made this clear. The abstract in The Popular Science Monthly for April states that the several-sized buds are on the same tree. It should be *at the same node or axis.* Of the three buds, *one above another*, the upper or largest produces a strong branch; the second in order and in size, a female flower; and the lowest, smallest, and least organized, the male catkin. The illustration is very pretty. No one should be satisfied to read about it, but examine the walnut-trees and see for himself.

Thomas Meehan, Philadelphia.

The Potato-Disease.—It is quite certain that the same stock grown on the same land, for several years in succession, deteriorates considerably; and, as the vigor of the plant declines, it becomes more and more susceptible to the influence of unfavorable weather. It will generally be found, says the *Gardeners' Magazine*, that in a year of disease the sorts regarded by the cultivator with interest as novelties, turn out the best; while those that have been grown on the same spot for several years, suffer most severely. The novelties usually come from a distance, and, irrespective of their intrinsic merits as varieties, they have this peculiar advantage, that they were raised on a different soil, and to some slight extent in a different climate from that they are used to depend on for subsistence.

Generally speaking, says the same magazine, the best seed for strong soils is that raised on peat and bog lands, and seed of excellent quality may be obtained from dry, calcareous soils and newly-broken, sandy pastures. It is very much the custom in England for traders who have to provide largely of seed-potatoes for their customers, to send certain sorts to growers occupying such lands, in order to secure vigorous stocks for cultivation the next year on strong, productive lands. The seed so obtained produces a cleaner crop in a bad season, and a heavier crop in a good season, than seed of the same sorts that has not enjoyed a change of soil for many years. Hence, purchased seed is, as a rule, better than that of the same sort home-grown.

Microscopic Aspects of the Potato-Disease.—Mr. Wenham, writing in the *Microscopical Journal* on the subject of potato-blight, says that a fungus, from the universal presence of the spores in damp localities, and its rapid growth, may appear simultaneously with morbid conditions, and yet not be the primary cause. The grape-vine disease, being cuticular, may be readily traced by the microscope to a fungoid origin, and this origin is further proved by the action of the sulphur-cure, so destructive to fungi in confined localities. This is of no avail in the potato-disease, which, under conditions favorable to its development, is internal and constitutional.

On placing a very thin slice of potato (taken at any time of the year) under the microscope, the cells are seen to be filled with starch-granules, and the walls coated with a layer of active protoplasm of the usual molecular appearance. In the healthy cell, this protoplasm, when seen under the highest powers, with suitable illumination, has a vibratory motion, with feeble currents, in various directions. On approaching the vicinity of the diseased portion, the cell-walls begin to appear of a light-brown color, and wherever the least tinge of this becomes apparent there is no movement, nor can any protoplasm be detected adhering to the wall of the cell, which from that time is a dead member.

Tracing the cell-walls farther, the color deepens, and the septa become thicker, till at last the walls split, giving the now rotten cell a detached appearance; but, from the first indication of disease to the final rotten state, no vital activity can be discovered. In all the phases the starch-granules remain unaltered, completely resisting this peculiar decomposition. The disease is evidently located throughout the tuber, in the substance of the cell-walls. Of its origin Mr. Wenham offers no opinion.

English Honors to an American Astronomer.—The British Royal Astronomical Society has awarded a gold medal to Prof. Simon Newcomb, Astronomer-in-Chief of the United States Observatory at Washington, for his Tables of Neptune and Uranus, and for other valuable astronomical work. The "Investigation of the Orbit of Uranus, with General Tables of its Motion," is the result of fifteen years of labor under the immediate supervision of Prof. Newcomb. Prof. Cayley, of the Astronomical Society, in presenting the medal to Dr. Huggins for transmission to Prof. Newcomb, spoke in very high terms of commendation of the Washington astronomer, and concluded as follows: "Prof. Newcomb's writings exhibit, all of them, a combination, on the one hand, of mathematical skill and power; and, on the other hand, of good, hard work, devoted to the furtherance of astronomical science. The memoir on the lunar theory contains the successful development of a highly-original idea, and cannot but be regarded as a great step in advance in the method of the variation of the elements and in theoretical dynamics generally. The two sets of planetary tables are works of immense labor, embodying results only attainable by the exercise of such labor under the guidance of profound mathematical skill—and which are needed in the present state of astronomy. I trust that, imperfectly as my task is accomplished, we have done well in the award of our medal."

Nature's Distribution of Trees.—In a note presented to the Philadelphia Academy of Sciences, Mr. Thomas Meehan held it to be an error to suppose that trees are by nature placed in conditions best suited to their growth. Almost all of our swamp-trees grow much better when they are transferred to drier places, provided the land is of fair quality. He referred, among others, to sweet bay, red maple, weeping-willow, and other trees, as within his own repeated observations growing better out of swamps than in them. The reason why they *originate* in swamps is that their seeds can germinate only in damp places, and, of course, in the state of nature, the tree remains where the seed has germinated. Plants, as a general rule, even those known as water-plants, prefer to grow out of water, except those which grow almost entirely beneath the surface. The *Taxodium distichum*, in the Southern swamps, sends up "knees" from various points, often as large as old-fashioned bee-hives, and several feet above the surface. Not only is the cypress as large when growing in good, rather dry ground, as when growing in swamps, but the tendency to throw up these knees is in a measure lost. With the general facts before us, of the antipathy of swamp-plants to submersion, Mr. Meehan thinks it safe to conclude that these root-excrescences were the result of an effort of the plant to counteract the law which held it, so to speak, in the place of its birth.

Determination of Oxygen dissolved in Water.—At the weekly meeting of the Lyceum of Natural History on Monday, February 16th, as we learn from the *Engineering and Mining Journal*, Prof. Wurtz read a paper on subaërial oxidation. The author is well known to have been for some time engaged in the study of the problems connected with the water-supply of cities. Among these problems, the question of what becomes of the nitrogenous compounds contained in sewage when poured into a running stream, is one of the most important. Oxidation goes on by the action of oxygen dissolved in the water, and Prof. Wurtz has long been studying the means of ascertaining the presence of oxygen in a given water, and of measuring its quantity. To do this he uses a color-test, employing for that purpose pyrogallene, which turns brown under the action of even infinitesimal quantities of oxygen. A sample of water is first made alkaline, and then a drop or two of a concentrated solution of pyrogallene in alcohol is added. If oxygen is present, the result is a brown tint; but, if an aqueous solution of pyrogallene is used, a beautiful pink is sometimes produced. With liquids containing infinitesimal quantities of oxygen, the aqueous solution of the reagent gives a pink color which gradually passes to purple and finally to brown. The depth of the color, therefore, varies with the amount of oxygen, and permits the estimation of the quantity present by the use of graduated standards.

English Fish in Indian Waters.—In December, 1867, Mr. McIvor, Superintendent of the Chinchona Plantations, on the Nilghiri Hills, in Southern India, took out carp, tench, trout, and other fish, with which he has now stocked the rivers, streams, and lakes, of the Nilghiris. The trout have not succeeded well, but the growth and increase of the tench have been marvelous. The first English fish were put in the lake at Utakamund, in August, 1869. In 1871 and 1872 the streams flowing into the lake were well stocked with fish, and for the last few months they have been caught in large numbers by the natives, and sold in the markets. The tench greatly predominate. One interesting fact is that many European fish have been caught below the great Kalhutty water-fall, showing that they have survived after being carried down the highest fall from the Nilghiris, in the descent of the Utakamund Lake and River to the plains. It may, therefore, be expected that the rivers from the foot of the hills to the sea will eventually be stocked with English tench.

A Clever Shepherd-Dog.—At a field trial of shepherd-dogs held at Bala, in Wales, last October, for a prize of fifty guineas, one of the contestants, a pure-bred Scotch colley, named Sam, performed some marvelous feats which have earned for his portrait a place in the *American Agriculturist.* The duty the dog had to perform was, to drive three sheep, just released from the fold, into a pen with an entrance six feet wide at about five hundred yards' distance. The difficult nature of the performance was increased by the great wildness of the small, wiry mountain-sheep of Wales, which leads them to go in any direction rather than the right one, and each one to scamper off in its own chosen direction. Sam, however, was not to be defeated, and, "surrounding" his three wayward sheep by rapidly-executed flank-movements, had them safely penned in eleven minutes and a half. Sam's next performance was rendered more difficult of accomplishment by sundry unlucky accidents. A flock of geese got mixed up with the sheep, but Sam cleverly extricated his flock. Then two of the sheep jumped over a stone-wall, and the third leaped into the river. Sam persuaded two to come back again, and then hauled the third out of the water by the scruff of the neck and soon had them all in the pen. But, by a mistake of his master, Sam lost too much time, and although his performances were by far the best in other respects, he was adjudged only the third place in the competition.

Eozoon Canadense.—It was the occasion of a great surprise to geological *savants*, when it was announced that the hitherto so-called azoic rocks of the Laurentian formation contained fossil remains. Certain dark-green spherules, not larger than pin-heads, were found speckling the mass, like caraway seeds in a cake. These specks were of hard green-stone, or serpentine. In Northern New York a limestone formation exists, in which these green spherules abound to such an extent as to color or mottle the rock, so that it is called verd-antique marble. These green globules are the same with those in the rocks of the St. Lawrence. They have now for a few years been known by the name *Eozoon Canadense.* Mr. H. J. Carter, in the *Annals and Magazine of Natural History*, as cited in the *American Journal of Science*, seems to have given *Eozoon Canadense* its death-blow. He declares that it is not a *Zoraminifer*, or calcareous rhizopod secretion. It was argued, by those who claimed for it a fossil character, that it was a *Zoraminifer* infiltrated with serpentine. Mr. Carter has made a study of infiltrated specimens of *Nummulites*, *Orbitoides*, and other minute fossils from the Eocene of Western India. These well preserved their foraminiferous structure. But of the *Eozoon Canadense* he says: "In vain do we look for the casts of true foraminiferous chambers at all in the grains of serpentine; they, for the most part, are not sub-globular, but sub-prismatic." He declares himself "at a loss to conceive how the so-called *Eozoon Canadense* can be identified with foraminiferous structure, except by the wildest conjecture."

If, then, this absence of structure thus puts out the claim of this so-called Eozoon, or "dawn of life," may it not be timely to ask what evidence of *structure* there may be in the so-called organism on which the recent attempt has been made to prove the existence of land-plants in the Silurian?

Jasmine flowering early.—For a little time the opening of the winter was severe, after which, until about the close of January, the season was exceptionally mild. It told on the budding of trees generally. At Washington, the *Jasminum nudiflorum*, a Japanese species of jasmine, is cultivated in the open air. This plant burst into bloom about the first of January, some twenty days earlier than is its habit in that latitude.

NOTES.

About 800 miles west of Omaha, says the *Scientific American*, the line of the Union Pacific Railroad crosses Green River, and the approach to the river is for a considerable distance through a cutting of from twenty to forty feet in depth, made in rock. During the construction of the road, some workmen piled together a few pieces of this rock for a fireplace, and soon observed that the stone itself ignited. It has been shown by analysis that the rock, which is a shale, yields by distillation some thirty-five gallons of oil per ton. The oil so obtained is of excellent quality, and comes over in two or three grades, one suitable for burning and the others for lubrication. The deposits of this rock are supposed to cover an area 150 miles long and 50 broad. They overlie the immense coal-beds of that region, and consist of sandstone impregnated with oil.

Thompson's article "On Cremation" has been twice translated into German, and published once at Cologne and once at Grätz, an Austrian city. The Grätz edition had an introduction by Dr. Kopl, at one time physician to the King of the Belgians. The Communal Council of Vienna has by a large majority adopted a proposal to establish in one of the public cemeteries the necessary apparatus for burning bodies, the use of which will be optional and open to all. The Council of Grätz has passed a resolution to the same effect.

Mr. J. L. A. Warren, author of a valuable treatise on "Silk Culture," is now in Europe, with the intention of visiting the different departments of silk culture and manufacture in France and Italy, and of collecting information for use in his new work on "Silk Culture in Europe and America," which is now in course of preparation.

The Cowles process for the preservation of clothing from moth and mildew, of which much has lately been said in Congress and in the press, is stated by the *Scientific American* to be based on the preservative action of sulphate of copper on vegetable fibres. By the addition of alum, the preserving qualities of the sulphate are, it is claimed, greatly enhanced; and, when gelatine is also combined, the fibres are said to be not only proof against decay, but also impervious to water. The ingredients are proportioned as follows: Alum, 2 lbs. dissolved in 60 lbs. water; blue-vitriol, 2 lbs. dissolved in 8 lbs. water, to which is added gelatine 1 lb. in 30 lbs. water. A still further improvement is said to made by the addition of acetate of lead, ½ lb. dissolved in 30 lbs. water. The solutions are all hot and separately mixed, with the exception of the vitriol, which is added cold.

Prof. H. Alleyne Nicholson, Professor of Natural History and Botany in University College, Toronto, has been appointed to the professorship of Zoology in the Royal College of Science, Dublin. Dr. Nicholson is the author of several well-known works on zoology, the most recent being a "Manual on Paleontology," for the use of students.

For the year closing January 1, 1874, the precious metals expressed by Wells, Fargo & Co., produced in North America, made the immense aggregate of $72,258,693. This is in excess of the production of 1872 to the amount of $10,000,000. Nevada alone transmits $35,254,507.

Prof. Gray mentions, in the *American Journal of Science and Art*, the discovery by Mr. E. J. Hill, on an island in the Kankakee River, in the northeastern part of Illinois, of the *Sphæralcea acerifolia*. This mallow was supposed to exist only in the Rocky-Mountain region and Oregon. Dr. Gray says of this plant, it "is one which probably came so long ago as when Lake Michigan discharged into the Mississippi, the lower part of the Kankakee River being in the direct course of the discharge. The present plants may more probably be regarded, not as chance stragglers, but as lingering remnants indicating an ancient habitat."

Prof. C. V. Riley, Missouri State Entomologist, has received the high compliment of a gold medal from the Minister of Agriculture and Commerce of France, in recognition of his discoveries in economic entomology, and in particular for services rendered to French grape-culture. It will be remembered that Prof. Riley discovered the American origin of the grape-vine louse, or *Phylloxera vastatrix*, an insect which threatens the utter destruction of the great vineyards of France. The medal is about an inch and a half in diameter, and bears on its face the figure of "Liberty" in bass-relief, with the words "French Republic." On the reverse is, "To Mr. Riley, of St. Louis, Mo., for services rendered to French viticulture, 1873," encircled by "Ministry of Agriculture and Commerce."

We note with pleasure the organization of the School and College Association of Natural History, of the State of Illinois. The objects of the Association are: first, to collect, study, and exchange specimens in natural history, and to contribute to a natural history survey of the State; second, to form a State museum; third, to obtain for the schools, with which its members are connected, suitable cabinets of specimens for study and reference; fourth, to encourage and assist the rational study of Nature by the pupils of our schools. An election of officers, on December 31, 1873, resulted in the choice of Dr. Richard Edwards, Normal School, Normal, Ill., for president; S. A. Forbes, curator; and Aaron Gove, secretary. The State Museum at Normal was designated as the centre of exchange and distribution.

A rich discovery of emery is reported to have been lately made in the northern portion of Pettis County, Missouri.

HERMANN LUDWIG FERDINAND HELMHOLTZ.

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HAVE PLANTS A PEDIGREE?

By Professor W. D. GUNNING.

WE have lately been reminded, by a writer in the *North American Review*, that the builders are the metaphysicians, and that science is only a brick-yard. How many, then, would quit the service? No! wiser we think were the words of the late Cambridge professor: "We have reached the point where the results of science touch the very problem of existence, and all thoughtful men are listening for the verdict which solves the great mystery." There is a great truth here which people are beginning to recognize, and there can be little doubt that the strongest hold which Science now has upon the public mind, comes from the light she is supposed to be able to throw on "the problem of existence." The vegetable kingdom has many aspects of interest, but Science has now raised the profound inquiry how it came to be—that is, the problem of its existence. We propose to set forth in this paper part of the testimony which plants give on the question of their origin.

In the floral world that which first catches the attention is color, and, although in classification it passes for almost nothing, no other property or quality affects the mind so deeply. The great poets, who are always wiser than they know, have literally *painted* the vices and virtues. Anger is *scarlet*—

> "The ashy paleness of my cheek
> Is *scarleted* in ruddy flakes of wrath."

Jealousy is *yellow;* modesty is *crimson;* melancholy is *blue;* cheerfulness, hopefulness, youth, are *green;* malice, vengefulness, falsehood, are *black*, and truth and purity have never been painted to the imagination more simply and beautifully than by Shakespeare in this:

> "White-robed truth;"

and by Milton in this:

> "The saintliest veil
> Of maiden-white."

May not color be of more importance in botany than the system-makers have supposed? How did flowers come by their colors?

If two colors are placed in juxtaposition, to produce the most pleasing effect they should be complementary, as red and green, orange and blue, yellow and purple. What, now, is Nature's method among her flowers?

He who has seen the calypso will remember it as the rarest of color-gems. The petals are of brilliant purple, the lip, deep within of gorgeous yellow, shades off into purple inoculated with darker purple. This floral gem is painted in two colors complementary to each other.

From calypso, which is rare, you pass to a flower of the same family which is not uncommon, the showy lady's-slipper (*Cypripedium spectabile*). In this we have three colors. The petals are snow-white, the lip is lustrous white melting into magenta, which in turn deepens into purple, and the sterile stamen, which mimics a petal and dips into the sac formed by the inflated lip, is pale yellow. The white of our lady's-slipper is the purple and yellow *blended* together; and we shall find, in general, that when a flower has three colors, two of which are complementary, the third will be *white*, representing the blending of the other two.

The wild-asters, like the calypso, are of two colors, the color of the ray being, in general, complementary to that of the disk, and thus the most common of our autumnal flowers are pleasing to the eye. The rose and English hawthorn are of one color, which harmonizes with the foliage, as red is the complement of green. But Nature has another side.

The corolla of the closed gentian, which is set in a green calyx, is deep blue. Here is chromatic discord.[1] The "lilac"-colored flowers of the lilac, in contrast with the green leaves, form another discord. No lady would think of dressing in lilac and green.

Our buttercups and golden-rods are yellow. In the golden-rod neither the yellow of the flower nor the green of the foliage is strongly marked, and the contrast is not displeasing. But the bright yellow of the buttercup against the fresh green of the leaves and the spring grass makes a chromatic discord. Green and yellow are not in accord, and Shakespeare, taking green for youth and yellow for jealousy, uses this color-discord with fine effect:

> "She never told her love,
> But let concealment, like a worm i' the bud,
> Feed on her damask cheek; she pined in thought,
> And with a *green and yellow* melancholy,
> She sat like patience on a monument,
> Smiling at grief."

[1] Green and blue—green tends to give its complementary, red, to the blue, which renders it more violet; blue tends to give its complementary, orange, to green, which renders it more yellow.

Traveling on a June day from Bangor to Boston, we observed all the meadows and waste fields through the shale region of Central Maine overrun with bulbous crowfoot — the *Ranunculus bulbosus.* The face of the earth over large patches was literally green and yellow, and the chromatic effect began to tell very unpleasantly on the eye. Passing from the shale into a region of granite we found the buttercups giving place to the white-weed (*Leucanthemum vulgare*). Over the pastures of Massachusetts this was as common as the buttercup in Maine, and the face of the earth was now *white* and green. The relief was felt at once. It was now a pleasure to look on the meadows. And yet the pleasure would have been still greater if the leaves and grass had been light blue instead of green, as white and light blue are in still better accord than white and green. But we will not be over-critical. A lady in white can wear a scarf, or sash, or breast-knot, of any color she may wish; and Nature, if she decks herself in white flowers, may set them in green, or brown, or red, or any tint she will, and there will be no discord.

The discords we have considered are between the flower and the foliage. There are others in the flower itself.

In the sweet-pea we have red and violet, a juxtaposition as discordant as that of green and blue. The bird-foot violet has the two upper petals of deep violet, the others of lilac-purple or blue—another discord. And such a collocation produces not merely a chromatic discord. Rays of blue and violet, entering the eye together, cause fluorescence of the cornea and crystalline lens. These parts become faintly luminous by the absorption of such light, and vision is rendered imperfect.

All this may seem fanciful. A field of green and yellow may appear to most eyes as pleasing as one of green and white. A violet, colored in violet and blue, may be called as beautiful as a calypso, in yellow and purple. But eyes which cannot see chromatic discord cannot see chromatic harmony. If a bad picture does not offend the taste, a good one cannot gratify it. There lies on our table a magazine printed in colored inks, an effort, the publisher tells us, to supplant the old monotony of black and white, and to minister to our love of color. It has a *yellow* cover bordered with *scarlet* and labeled in *green!* Flowers may not be guilty of chromatic offenses so atrocious as this, but such offenses they certainly do commit.

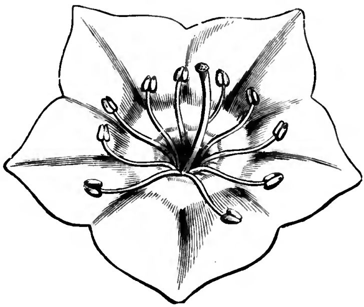
What is the end of floral decoration? By the old way of interpreting Nature, the botanist would have said, "To gratify man's love of the beautiful." He would not give such an answer now. If he would explain why certain flowers are not colored at all, and how it has come about that other flowers are colored, some in chromatic harmony, and others not, he must look to the flowers themselves, and to their servants the insects. Every one knows that the pollen must find its way from the anther to the stigma, else the flower, lacking impregnation, can set no seed. For many trees, and for grasses generally, the office of transporting the pollen is performed by the wind. And, "as the wind bloweth where it listeth," it may waste a million pollen-grains for every one it lodges on a stigma. Hence the prodigality of pollen. If you walk through a field of corn, you will note how generously the tassel yields its pollen to the wind. If, toward the last of May, you shake a branch of pine, you will see floating from it a cloud of pollen-grains.

Having seen the largest prodigality, we will search now for the closest economy.

In many of the violets we find, in addition to the showy flowers, another set borne on runners and concealed under leaves. In the fringed polygala we have another case of dimorphism. In one flower the petals are of richest pink, two of them spreading out like wings, and the other, keel-shaped, crested and fringed. Another flower, which never opens, is borne close to the ground, or even in the ground, on subterranean shoots. Now, these ground flowers of the violet and polygala are self-fertilizing. One grain of pollen is enough for one seed, and that is all which Nature, in these flowers, will furnish.

You will observe now that the pine and the corn, in general all conifers and grasses depending for fertilization on the wind, have colorless flowers and much pollen, and that concealed flowers are without color and have but little pollen. We begin to suspect that color stands in some relation to the needs of the flower. In the grasses and pines it would be of no use, as the wind will find a dull flower as easily as a gaudy one. In self-fertilizing flowers it is also of no use.

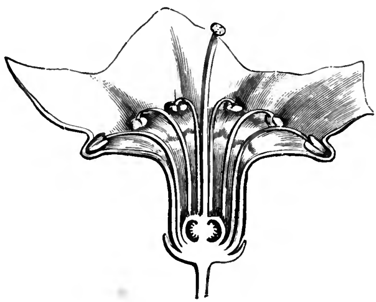
Fig. 1.



Eighty years ago Sprengel maintained that breeding in and in would be as injurious in the vegetal as in the animal world, and he argued that colors and odors attract insects and thus secure cross-fertilization. It was the largest thought which had ever entered the head of a botanist. But Sprengel was ridiculed in his own generation and forgotten in the next. Thirty years ago Charles Darwin discovered the German's idea in an old, castaway volume, and at once he began to employ his matchless powers of observation in questioning Nature for its truth. He has taught us how to use our eyes. Let us look.

One of our most beautiful shrubs is the mountain-laurel (*Kalmia latifolia*). It blossoms all over in corymbs of bell-shaped flowers, white, tinged with red, having short nectaries and recurved stamens, whose anthers are inserted in little pits of the corolla. In Fig. 1 the flower is shown with the anthers out of their sockets. In Fig. 2 we have a section of the flower showing the recurved stamens and the anthers resting in their pouches. It will be seen that the stamens are shorter than the style. How is the anther to be liberated from the pouch? And how is the pollen to be carried to the stigma?

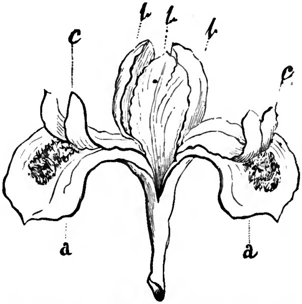
Fig. 2.



The kalmia is one of the most showy shrubs along the wooded waysides of New England, and is very attractive to bumble-bees. Now, your bumble-bee is the clumsiest of insect. His action is as ungraceful as his person. He can do nothing expertly and neatly. He cannot even sting you while on the wing, but must first alight and adjust himself. At nectar-getting he is as clumsy as at stinging. He *sprawls* over a flower, pushes here and there among the delicate organs, and gets himself thoroughly bedaubed with pollen. This clumsiness makes him a good marriage-priest for the flowers. The color of the laurel attracts him, and the nectary promises honey. He lights, gets his legs entangled among the stamens, and as he jostles them they spring from their little pits with a sharp snap and scatter their pollen over his back. In visiting another flower some of the pollen will find its way to the stigma and thus secure cross-fertilization.

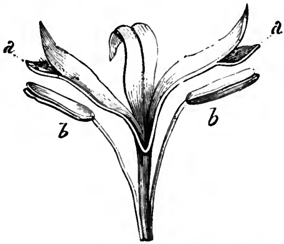
The iris would seem, at first thought, to have been specially planned for *self*-fertilization. As will be seen in Fig. 3, the petaloid stigma covers the petaloid stamen. But a most curious fact is that, while the stigmatic surface is brought right up against the stamen, the *anther* is turned outward away from the stigma. This arrangement will be seen in Fig. 4, which presents a longitudinal section of the flower after the petals have been removed. It is as if you apply powder to the surface of one sheet of paper and mucus to the surface of another, and, intending that the powder should be brought into contact with the mucus, place the two sheets together, surface to surface,

Fig. 3.



Flower of an Iris, or Flower-de-Luce: *a, a*, two of the three outer petals; *b b b*, the three inner petals; *c c*, two of the branches of the petal-like style.

Fig. 4.



A Longitudinal Section of Fig. 4: two branches of the style being cut through, show the plate-like stigmas *a a*, which loop the anthers *b b*.

but turn the *powdered* surface out. What a seeming design, and yet, seemingly, what a fatal blunder! But this is nature as manifested in the iris. Pollen and stigma, so close together, are separated by the blade of the stamen. But for insects which, attracted by the color, light, and search the flower for its nectar, and push, now against an anther and now against a stigma, the iris could never set a seed.

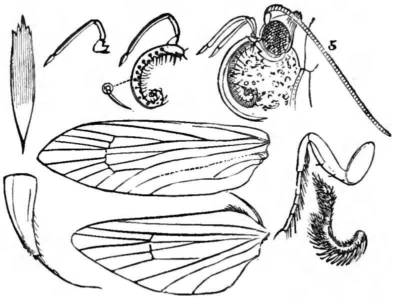
Flowers, as Dr. Gray has said, seem to be made on the principle, "how not to do it." By traps, and pits, and springs, insects are made to do by indirection what it would seem could be better done directly by the flower itself. For many flowers the service can be rendered as well by one nectar-loving insect as another. But in some species the parts are so modified that only a single species of insect, correspondingly modified, can reach the organs of fructification. In the northern part of the United States the yucca (Fig. 5) has never been known to set seeds.

An entomologist has lately discovered a small moth with white head and thorax and wings, and legs of dingy yellow. To this moth he has given the name *Pronuba yuccasella*—yucca's go between. The structure of this moth will be seen in Fig. 6. In Fig. 7 the larva and the moth are drawn in the natural size. The peculiarity of this moth is, that in the female the basal joint of one of the maxillary palpi (Fig. 6, 5) is modified in a most wonderful manner into a long prehensile tentacle. With this she collects the pollen and thrusts it into the stigmatic tube against the stigma. In this pollen-mass she lays her eggs. A single palpus of the female of a single species of moth, modified in a peculiar way, is the means of perpetuating the yucca. In its native home yucca and yuccasella are inseparable. In the north, yuccasella does not thrive and yucca can set no seeds.

Fig. 5.

Well, if plants depend so much on insects, insects must have some way of knowing where they are. As an optical instrument, the eye of an insect is rather imperfect, but it is not color-blind. A butterfly may not be sensitive to the harmonies of color, but it certainly knows a colored object from an object not colored. We need more observations before we can safely say that insects apprehend the different shades of color, and prefer one shade to another; but, if any one will watch bees on a bed of hyacinths, he will see that a particular bee is apt to confine itself to a particular color.

Fig. 6.

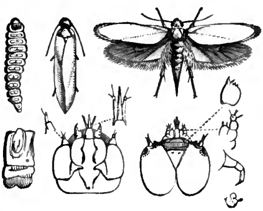


(Riley.)

We conclude that color and nectary are in correlation with the organs of fructification and with the eyes and appetites of insects.

Odor must come under the same law as color. We must seek for its *rationale* in the flower itself and the forces or agents which act on it. The hidden flowers of violet and polygala are odorless as well as

Fig. 7.



(Riley.)

colorless. The grasses, pines, and palms, whose pollen is borne on the wind, are inconspicuous in color and are generally without odor. But some species of palm require the visitation of insects, and while their flowers remain inconspicuous in color they are rich in perfume. The fan-palm of the Rio Negro perfumes the air far and near with the odor of mignonette. Myriads of insects, attracted by the fragrance, hum and buzz among the flowers, and carry pollen from the staminate to the pistillate ones. This odor is pleasant to man as well as insects.

But there are floral odors as well as colors which are offensive. We do not understand the laws of odor so well as those of sound and color. We educate the eye and the ear, but in the nose we are still cave-men. If we can trust a *savant* who has spent years in the cultivation of his olfactories, odors are under the same law as sounds and colors. Certain odors blend into a sort of music of smells as certain notes into a music of sounds. Other odors refuse to blend, but jar on the nose like discordant sounds on the ear. Septimius Piesse must live in a world of harsh notes and grating discords. Even to us the account seems nearly balanced between the odorous and the mal-odorous. The wild-rose is sweet, but the datura is sickening. The ailantus may be scored against the pink, and against the jasmine, the queen of flowers, whose fragrance is the only secret the floral world withholds from our chemistries—against the jasmine may be scored the carrion-flower. The odor of the flower is what its name implies. Surely it was not given for man's pleasure. Then for what? Perhaps from this very flower we may learn the *rationale* of odors.

The flower of the carrion-plant is of a pale yellow-green and is altogether inconspicuous. If it had no attraction but its color, it would never win the attention of an insect. Now, it is a fact of great significance that this carrion-flower is fertilized by the blow-fly. But what does the blow-fly want of a flower? If this flower were sensitive and rational and skilled in chemistries, we might imagine the correlation between itself and the fly to be the result of a mental process something like this: "At any cost I must secure fertilization. The wind cannot serve me, and bees and butterflies cannot find me. I will invite the blow-fly—I will practise deception. I will smell like decaying flesh!" Of course, this is fanciful. Suppose we imagine an intelligence *outside* of the plant, and the insect arranging by special creation such correlations between color, odor, nectary, and bees, moths, flies, and butterflies. Does it bring us any nearer to a mental resting-place? Rather, do not questions without end start up in the mind? Why such indirection? Why such seeming design marred by seeming chance as in the iris? And if all these structures and colors and odors are the result of special creation, what shall we say of deadly nightshades? of poison-ivies? of the fungi which live on the human body? Was there a special provision for certain fungi to grow on the forehead? for others to thrive in the mouth? for others still to infest the stomach? Was the body of man designed to be the habitat of pain-giving parasites? We have found plants good and not good, beautiful and not beautiful, odorous and mal-odorous. If the world were a theophany, would it not be good only, good everywhere and equally? To interpret the vegetal world as a "special creation" no more satisfies the religious sentiment than the reason.

Our common loosestrife (*Lysimachia quadrifolia*) is one of the most variable of species. Its European representative (*L. vulgaris*) appears in two well-marked varieties: one, found in sunny localities, whose petals are dark yellow, with red at the base; and the other, growing by shaded ditches, with petals of light yellow, and no red at the base. The more conspicuous variety attracts insects, and, as the stigma overtops the stamens, the agency of insects is required to secure fertilization. The flowers of the less conspicuous variety are not visited by insects, and, as the stigma does not overtop the stamens, the agency of insects is not required. The flower is self-fertilizing. These two forms graduate into each other, by connecting links which are found on the *sunny* edges of ditches.

Here is a very instructive lesson. Greater amounts of sunlight will account for the richer color of one variety; and the agency of insects, attracted by the color, will account for the change in structure. We see Nature in the act of species-making. Insects, acting mechanically on the delicate organs of a plant, effect something more than fertilization. Let us consider this action more carefully.

Dr. Ogle has observed the manners of the bee in visiting beans and scarlet-runners. These flowers are arranged to secure cross-fertilization. The honey they offer must be taken by an insect which will enter by the open door of the corolla-tube. But Dr. Ogle observed that while certain bees visit the flower in the legitimate way, and thus carry pollen from anther to stigma, others have a trick of evading their duty by piercing a hole in the calyx-tube, thus securing the nectar by a short cut. An important fact noted in these observations is, that the same bee always visits a flower in the same way. The inference is, that this habit of nipping the calyx is the result of individual experience. As some bees have acquired the habit, and others have not, another inference is that these insects are intelligent, and that they differ from each other in *degrees* of intelligence. Our final inference is that, if all bees are ever schooled up to this new art, there must come an end to our beans and scarlet-runners—unless some modification should occur in the structure of their flowers.

The salvia is constructed as if with special reference to fertilization by bumble-bees. But Mr. Meehan, who first pointed out the correlation, never saw a bumble-bee enter the flower. Under his eye the bee always cut the tube of the corolla. But another observer *has seen* the bumble-bee enter the flower and effect fertilization. And he has seen it nipping the corolla-tube to secure the honey by a short cut. *And he has noticed that the smaller bees entered the corolla-tube, and that those which were too large to get into the flower nipped the tube.* This is an important observation, and brings us to the very heart of the matter. The salvia with small corolla-tube, not securing fertilization, stands but little chance of surviving. The flower with large tube invites the bee, is fertilized, and ripens seed. "Natural selection" is going on under our very eyes. Now, if, in "the struggle for existence," a larger race of bumble-bees should appear, the salvia must either vary with the varying insect, or die out. And we have no right to assume that the *body* of an insect is a fixed bulk or structure any more than that the "instinct" or intelligence is fixed and invariable. Prof. Riley has shown the extreme probability that the peculiar modification of the palpus of the female yuccasella, which makes her the marriage-priestess of the yucca, was brought about little by little, as the peculiar structure of the flower came little by little. Flowers *must* vary with insects, and insects with flowers—yucca with yuccasella, and yuccasella with yucca—or both must die.

We have now the *rationale* of colors and odors. As vitality seems to have some general relation to color, perhaps the first show of color in a floral envelope was due to a slight diminution of vital force.[1] Color being advantageous to the plant by attracting insects, when once it appeared its shades would be multiplied and intensified age after age, by natural selection. And as color is developed little by little as the result of insect-vision, modifications of structure are developed, in equal pace, by insect-touch.[2]

This is not all. An organism is modified by all which environs it. Mr. Spencer, in his great work on "Biology," has shown us that the form of the cell, the leaf, the branch, the trunk, the flower, is determined in great part by the environment. Varying amounts of sunshine or shade modify the form of a branch. A prevailing wind modifies the form of a tree. A change of position on the stem changes the form of a flower. The drooping gloxinia in your conservatory is *bi-symmetrical*, and has a rudimental fifth stamen. Culture brings the flower up, erect on the stem, makes it *radically* symmetrical, restores the rudiment to a perfect stamen, prunes the flower of its eccentricities, and makes it *regular*—just as it does with a man.

Nature is, in the plant, what her name implies, "*natura*," a something about to be, a continual becoming. We see what changes are going on in the garden. Changes the same in kind are going on in the fields and the woods. A stroll over Goat Island on any May day will show the observant eye how variable in size and color and even in structure is the *Trillium grandiflorum*. The white-weed which overruns our Eastern meadows has sported into a score of incipient varie-

[1] White is excess of color, and every florist knows that a plant with white flowers has pale leaves and stem, as if the entire plant were in sympathy with the petals, and were lacking in vitality.

[2] A recent writer has said that, if chance were the ruler of the world, it would not be the *highest* ruler, as the law of chances is higher than chance itself. If the coloring of flowers, he would say, were even a thing of chance, still, by this law, the blending of colors and their juxtaposition, in the main, would show some kind of order. But we can account for the prevalence of pleasing colors and odors without falling back on the law of chances. Very low down in organic Nature is the sense of beauty. A bright color is bright to the eye of a bee as well as to our own. In the course of time those odors and that display of color most pleasing to the senses would, by natural selection, become prevalent and hereditary.

ties, and, although but a new-comer on our shores, already in Connecticut it appears in a variety fixed and well marked. Incipient doubling is not uncommon, and now and then may be found a thalictrum or a saxifrage full-double. From the wild-strawberry (*Fragaria Virginiana*) has diverged a well-marked variety called the *F. Illinoensis*. From this has diverged still another variety found by Mr. Gillman in great abundance on the shores of Lake Superior, far away from the influence of the gardener—a variety of a variety.

And now, as the visitation of insects, as more or less light, more or less heat, more or less wind, more or less room, more or less soil, are known to effect changes in the color, size, form, and even structure

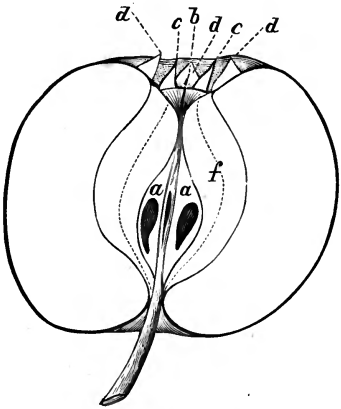
Fig. 8.

Water-lily—(*Nymphæa odorata*).

of plants, if the vegetal world has come to be what it is through the action of these secondary causes, we should find reminiscences of a primitive, undifferentiated type.

Theoretically the plant is a leaf. The axis or stem is a fused series of midribs. The floral organs are leaves variously modified. Nay, we may look even beyond the leaf to the components of the leaf, for thought cannot rest till it finds the ultimate unit. This is a cell, and the lowest plant is *simply* a cell. Cells adherent to cells form a frond. A frond, by a little modification, passes into a leaf, and a leaf into a part of the flower. A sepal is a leaf changed but little; a petal is a leaf changed in color and texture; a stamen is a leaf changed in color, texture, and form, the blade being eliminated except at the tip where it forms the anther, and the midrib remaining as a supporting filament; the pistil is a leaf with the lower part of the blade rolled up, and the edges united to form a carpel, and the midrib prolonged into a style, bearing atop a little shred of altered leaf-blade called a stigma. And here—at the very tips of these inner leaves where the nutriment is least and the vital force weakest—the investing membrane disappears; Nature slips back toward her simplest types, and shows us the naked primordial cells as pollen-grains! In the thistle one may see that the stem is continuous with the midrib of the leaf. Every observer knows that in the pond-lily (Fig. 8) we see the intermediate stages between a simple leaf and a pistil. And every one whose garden furnishes a syringa or double-flowering cherry, has only to look at the flowers to see pistils and stamens reverting to leaves.

Fig. 9



Section of an Apple.
a a, carpels; *b*, remnant of pistils; *c c*, remnants of corolla; *d d*, remnants of calyx; *f*, fibrous line.

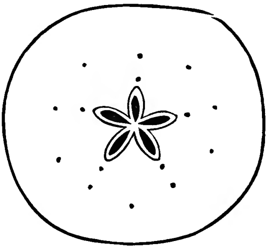
Fortunately for science, there grows in Kittanning, Pennsylvania, an apple-tree, which, in its flower and fruit, exemplifies the theory of the plant. Theoretically, a fruit is a branch with its leaves transformed.

If the reader will take an apple—a rotten one is best—and cut it through from flower-scar to stem, he will find a core of five carpels, and about midway between the core and the rind he will see a green, fibrous line (Fig. 9). If he will look now at the flower, he will find the cup or calyx of five sepals, the corolla of five petals, the stamens many (a number of whorls), and the pistils five (one whorl). We have shown that these floral organs are simply transformed leaves, and we shall now see that the apple itself is merely these leaf-whorls still further transformed.

Let us cut the apple through around the equator and compare our section (Fig. 10) with the longitudinal one (Fig. 9). Looking at the flower-scar, we see the remnants of the sepals, *d*, *d*, *d*. Within and alternating with these are remnants of the petals, *c*, *c*. Still farther within is a little shred of a pistil, *b*. This shred can be traced down into the core, *a*. The other parts of the flower lose themselves in the fleshy fruit.

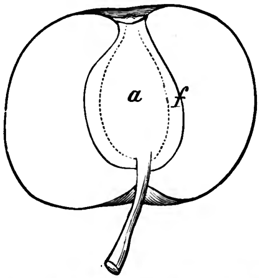
If we look now at the other section (Fig. 10), we shall see, on that fibrous line, ten greenish points, five opposite to the carpels and five alternating with them. Five other little points appear near the tips of the carpels and in line with them. Now, this fibrous line, and the points on it and within it, must bear some relation to the plan of the flower. And, as the stamens are a multiple of five, the points must have some relation to the staminate whorls. The core, as we see (Fig. 9), is continuous with the pistil. It is simply the base of the

Fig. 10.



Cross-Section of Apple, showing the Carpels and Fibrous Points.

Fig. 11.



Section of the Kittanning Apple. *a*, cavity which takes the place of the carpels; *f*, fibrous line.

pistillate whorl. The part of the fruit between the core and the dotted line represents the thickened and coalesced whorls of stamens and petals.[1] The fruit between this dotted line and the fibrous line represents the thickened petals. The fibrous line represents the union of

[1] This line is not found in the fruit. It is ideal.

the coroline with the calycine leaves, and the fruit between this line and the rind represents the calycine leaves, grown thick and succulent.

Now, the flower of this Kittanning tree appears as a mere rudiment. How, if this theory is true, should the *fruit* appear? The pistillate whorl is wanting, and in theory the apple should have no core. It has none, but in its place a large cavity, as shown in Fig. 11. The stamens are rudimental, and the petals are represented by five little bud-scales. Theoretically, then, we should find but little fruit between the core-cavity and the fibrous line. There is but little, as the cut will show. The calyx is better developed, and we should find more fruit between the fibrous line and the rind—as we do. The flower starts with all the essential organs of a flower, and, before the inner whorls are arrested, enough vitality is given to the outer whorl to start it on the way toward an apple. And with the lack of development in the inner whorls the outer one develops cork cells, and the rind takes on the character of bark!

This is Nature teaching by what is abnormal. Let us scrutinize her where she seems most regular and orderly.

The acorn, like the apple, is seen by everybody and known by scarcely anybody. We will take a full-grown acorn in its cup and cut it through about midway from top to base. We shall find five little roundish bodies pressed up close against the shell. What are they? and how came they here? We consult the flower, and find (in the fertile one) a style with a three-lobed stigma. The pistil, then, represents three transformed and infolded leaves. When the flower is a little more advanced, we will cut through the lower part of the pistil and examine a section. This part becomes the ovary, and we find in our section three partition-walls radiating from the circumference to the centre and dividing the ovary into three compartments. In this tripartite structure we find our three leaves, the infolded blades cohering along parts of their surface and forming the partition-walls. On each of these partitions we see two ovules. The ovules represent leaves budding out on the margin of the pistil-leaf, and thus every ovary, in theory, should have at the very least as many ovules as there are leaves composing it. In the flower we have now the plan of the acorn. The surface of the ovary will become a shell. The six ovules will grow and ripen into six seeds. Cutting through the shell of the full-grown acorn we shall find it to contain three chambers, and each chamber two naked acorns. We find nothing of the sort! Where was the slip? Early in the acorn's life one of the six ovules gets the start of its neighbors and takes to itself all the nutriment. It grows too large for its chamber, and breaks the partition-walls. It grows to the measure of all the chambers, fills them, and pushes its shriveled brethren up against the shell-wall where you see them, five little starved-out things which once were possible oaks! Strange, is it not? And how passing strange if the oak were made so by "special creation!"

What perplexity does the thought, coupled with the facts, bring into the mind! But if these aborted ovules are reminiscences of an earlier age, and an acorn less differentiated from the general type of the ovary, the oak becomes intelligible. And in this light of evolution all aborted organs, all rudimental organs, all floral eccentricities, become intelligible. Botany itself ceases to be a toy, and commands the attention of such imperial minds as those of Spencer and Mill. Her boundaries are enlarged. The plant does not stand apart, the result of a single antecedent. It represents the action of countless forces through countless ages. It almost justifies Tennyson's apostrophe:

> "Flower in the crannied wall,
> I pluck you out of the crannies—
> Hold you here, root and all, in my hand,
> Little flower—but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is."

PUNISHING A SENIOR WRANGLER.

By HERBERT SPENCER.

IN the *British Quarterly Review* for January, 1874, the writer of the article to which I formerly replied,[1] makes a rejoinder. It is of the kind which might have been anticipated. There are men to whom the discovery that they have done injustice is painful. After proof of having wrongly ascribed to another such a nonsensical belief as that insensible motion is heat because heat is insensible motion, some would express regret. Not so my reviewer. Having by forced interpretations debited me with an absurdity, he makes no apology; but, with an air implying that he had all along done this, he attacks the allegation I had really made—an allegation which is at least so far from an absurdity, that he describes it only as not justified by "the present state of science." And here, having incidentally referred to this point, I may as well, before proceeding, deal with his substituted charge at the same time that I further exemplify his method. Probably, most of those who see the *British Quarterly* will be favorably impressed by the confidence of his assertion; but those who compare my statement with his travesty of it, and who compare both with some authoritative exposition, will be otherwise impressed. To his statement that I conclude "that friction must ultimately transform *all* [the italics are his] the energy of a sound into heat," I reply that it is glaringly untrue: I have named friction as a second cause. And when he pooh-poohs the effect of compression because it is "merely momentary," is

[1] *See* POPULAR SCIENCE MONTHLY for March, 1874.

he aware of the meaning of his words? Will he deny that, from first to last, during the interval of condensation, heat is being generated? Will he deny to the air the power of radiating such heat? He will not venture to do so. Take, then, the interval of condensation as one-thousandth of a second. I ask him to inform those whom he professes to instruct, what is the probable number of heat-waves which have escaped in this interval. Must they not be numbered by thousands of millions? In fact, by his "merely momentary," he actually assumes that what is momentary in relation to our time-measures is momentary in relation to the escape of ethereal undulations!

Let me now proceed more systematically, and examine his rejoinder point by point. It sets out thus:

"In the notice of Mr. Spencer's works that appeared in the last number of this *Review*, we had occasion to point out that he held mistaken notions of the most fundamental generalizations of dynamics; that he had shown an ignorance of the nature of proof in his treatment of the Newtonian Law; that he had used phrases such as the Persistence of Force in various and inconsistent significations; and more especially that he had put forth proofs logically faulty in his endeavor to demonstrate certain physical propositions by *a priori* methods, and to show that such proofs must exist. To this article Mr. Spencer has replied in the December number of the *Fortnightly Review*. His reply leaves every one of the above positions unassailed."

In my "Replies to Criticisms," which, as it was, trespassed unduly on the pages of the *Fortnightly Review*, I singled out, from his allegations which touched me personally, one that might be briefly dealt with as an example; and I stated that, passing over other personal questions, as not interesting to the general reader, I should devote the small space available to an impersonal one. Notwithstanding this, the reviewer, in the foregoing paragraph, enumerates his chief positions; asserts that I have not assailed any of them (which is untrue); and then leads his readers to the belief that I have not assailed them because they are unassailable.

Leaving this misbelief to be dealt with presently, I continue my comments on his rejoinder. After referring to the passage I have quoted from Prof. Tait's statement about physical axioms, and after indicating the nature of my criticism, the reviewer says:

"Had Mr. Spencer, however, read the sentence that follows it, we doubt whether we should have heard aught of this quotation. It is: 'Without further remark we shall give Newton's Three Laws; it being remembered that, as the properties of matter might have been such as to render a totally different set of laws axiomatic, *these laws must be considered as resting on convictions drawn from observation and experiment, and not on intuitive perception.*' This not only shows that the term 'axiomatic' is used in the previous sentence in a sense that does not exclude an inductive origin, but it leaves us indebted to Mr. Spencer for the discovery of the clearest and most authoritative expression of disapproval of his views respecting the nature of the Laws of Motion."

Let us analyze this "authoritative expression." It contains several startling implications, the disclosure of which the reader will find not uninteresting. Consider, first, what is implied by framing the thought that "the properties of matter might have been such as to render a totally different set of laws axiomatic." I will not stop to make the inquiry whether matter, having properties fundamentally unlike its present ones, can be conceived; though such an inquiry, leading to the conclusion that no conception of the kind is possible, would show that the proposition is merely a verbal one. It will suffice if I examine the nature of this proposition that "the properties of matter *might have been*" other than they are. Does it express an experimentally-ascertained truth? If so, I invite Prof. Tait to describe the experiments. Is it an intuition? If so, then, along with doubt of an intuitive belief concerning things *as they are*, there goes confidence in an intuitive belief concerning things *as they are not*. Is it an hypothesis? If so, the implication is that a cognition of which the negation is inconceivable (for an axiom is such) may be discredited by inference from that which is not a cognition at all, but simply a supposition. Does the reviewer admit that no conclusion can have a validity greater than is possessed by its premises? or will he say that the trustworthiness of cognitions increases in proportion as they are the more inferential? Be his answer what it may, I shall take it as unquestionable that nothing concluded can have a warrant higher than that from which it is concluded, though it may have a lower. Now, the elements of the proposition before us are these: *As* "the properties of matter might have been such as to render a totally different set of laws axiomatic" (*therefore*) "these laws [now in force] must be considered as resting . . . . not on intuitive perception:" that is, the intuitions in which these laws are recognized must not be held authoritative. Here the cognition posited as premiss is, that the properties of the matter might have been other than they are; and the conclusion is that our intuitions relative to existing properties are uncertain. Hence, if this conclusion is valid, it is valid because the cognition or intuition respecting what might have been is more trustworthy than the cognition or intuition respecting what is! Skepticism respecting the deliverances of consciousness about things as they are is based upon faith in a deliverance of consciousness about things as they are not!

I go on to remark that this "authoritative expression of disapproval" by which I am supposed to be silenced, even were its allegation as valid as it is fallacious, would leave wholly untouched the real issue. I pointed out how Prof. Tait's denial, that any physical truths could be reached *a priori*, was contradicted by his own statement respecting physical axioms. The question thus raised the reviewer evades, and substitutes another with which I have just dealt. Now I bring forward again the evaded question.

In the passage I quoted, Prof. Tait, besides speaking of physical "*axioms*," says of them that due familiarity with physical phenomena gives the power of seeing "*at once*" "their *necessary* truth." These last words, which express his conception of an axiom, express also the usual conception. An axiom is defined as a "self-evident truth," or a truth that is seen *at once;* and the definition otherwise worded is—a "truth so evident *at first sight* that no process of reasoning or demonstration can make it plainer." Now, I contend that Prof. Tait, by thus committing himself to a definition of physical axioms identical with that which is given of mathematical axioms, tacitly admits that they have the same *a priori* character; and I further contend that no such nature as that which he describes physical axioms to have, can be acquired by experiment or observation during the life of an individual. Axioms, if defined as truths of which the *necessity* is at once seen, are thereby defined as truths of which the negation is inconceivable; and the familiar contrast between them and the truths established by individual experiences is, that these last never become such that their negations are inconceivable, however multitudinous the experiences may be. Thousands of times has the sportsman heard the report that follows the flash from his gun, but still he can imagine the flash as occurring silently; and countless daily experiments on the burning of coal leave him able to conceive coal as remaining in the fire without ignition. So that the "convictions drawn from observation and experiment" during a single life can never acquire that character which Prof. Tait admits physical axioms to have: in other words, physical axioms cannot be derived from personal observation and experiment. Thus, otherwise applying the reviewer's words, I "doubt whether we should have heard aught of this quotation" to which he calls my attention, had he studied the matter more closely; and he "leaves us indebted to" him "for the discovery of" a passage which serves to make clearer the untenability of the doctrine he so dogmatically affirms.

I turn now to what the reviewer says concerning the special arguments I used to show that the first law of motion cannot be proved experimentally. After a bare enunciation of my positions, he says:

> "On the utterly erroneous character of these statements we do not care to dwell, we wish simply to call our reader's attention to the conclusion arrived at. Is that a disproof of the possibility of an inductive proof? We thought that every tolerably educated man was aware that the proof of a scientific law *consisted in* showing that, *by* assuming its truth, we could explain the observed phenomena."

Probably the reviewer expects his readers to conclude that he could easily dispose of the statements referred to if he tried. Among scientific men, however, this cavalier passing over of my arguments will perhaps be ascribed to another cause. I will give him my reason for saying this. Those arguments, read in proof by one of the most eminent physicists, and by a specially-honored mathematician, had their entire concurrence; and I have since had from another mathematician, standing among the very first, such qualified agreement as is implied in saying that the first law of motion cannot be proved by terrestrial observations (which is in large measure what I undertook to show in the paragraphs which the reviewer passes over so contemptuously). But his last sentence, telling us what he thought "every tolerably educated man was aware" of, is the one which chiefly demands attention. In it he uses the word *law*—a word which, conveniently wide in meaning, suits his purpose remarkably well. But we are here speaking of physical *axioms*. The question is, whether the justification of a physical axiom consists in showing that, by assuming its truth, we can explain the observed phenomena. If it does, then all distinction between hypothesis and axiom disappears. Mathematical axioms, for which there is no other definition than that which Prof. Tait gives of physical axioms, must stand on the same footing. Henceforth we must hold that our warrant for asserting that "things which are equal to the same thing are equal to one another" consists in the observed truth of the geometrical and other propositions deducible from it and the associated axioms—the *observed* truth, mind; for the fabric of deductions yields none of the required warrant until these deductions have been tested by measurement. When we have described squares on the three sides of a right-angled triangle, cut them out in paper, and, by weighing them, have found that the one on the hypothenuse balances the other two, then we have got a fact which, joined with other facts similarly ascertained, justifies us in asserting that things which are equal to the same thing are equal to one another! Even as it stands, this implication will not, I think, be readily accepted; but we shall find that its unacceptability becomes still more conspicuous when the analysis is pursued to the end.

Continuing his argument to show that the laws of motion have no *a priori* warrant, the reviewer says:

> "Mr. Spencer asserts that Newton gave no proof of the Laws of Motion. The whole of the 'Principia' was the proof, and the fact that, taken as a system, these laws account for the lunar and planetary motions, is the warrant on which they chiefly rest to this day."

I have first to point out that here, as before, the reviewer escapes by raising a new issue. I did not ask what he thinks about the "Principia" and the proof of the laws of motion by it; nor did I ask whether others at this day hold the assertion of these laws to be justified mainly by the evidence the Solar System affords. I asked what Newton thought. The reviewer had represented the belief that the second law of motion is knowable *a priori*, as too absurd even for me openly to enunciate. I pointed out that since Newton enunciates it openly under the title of an axiom, and offers no proof whatever of it, he did explicitly what I am blamed for doing implicitly. And thereupon I invited the reviewer to say what he thought of Newton. Instead of answering, he gives me his opinion to the effect that the laws of motion are proved true by the truth of the "Principia" deduced from them. Of this hereafter. My present purpose is to show that Newton did not say this, and gave every indication of thinking the contrary. He does not call the laws of motion "hypotheses;" he calls them "axioms." He does not say that he assumes them to be true *provisionally*, and that the warrant for accepting them as actually true will be found in the astronomically-proved truth of the deductions. He lays them down just as mathematical axioms are laid down—posits them as truths to be accepted *a priori*, from which follow consequences which must therefore be accepted. And, though the reviewer thinks this an untenable position, I am quite content to range myself with Newton in thinking it a tenable one—if, indeed, I may say so without undervaluing the reviewer's judgment. But now, having shown that the reviewer evaded the issue I raised, which it was inconvenient for him to meet, I pass to the issue he substitutes for it. I will first deal with it after the methods of ordinary logic, before dealing with it after the methods of what may be called transcendental logic.

To establish the truth of a proposition postulated, by showing that the deductions from it are true, requires that the truth of the deductions shall be shown in some way that does not directly or indirectly assume the truth of the proposition postulated. If, setting out with the axioms of Euclid, we deduce the truths that "the angle in a semicircle is a right angle," and that "the opposite angles of any quadrilateral figure described in a circle are together equal to two right angles," and so forth; and, if, because these propositions are true, we say that the axioms are true, we are guilty of a *petitio principii.* I do not mean simply that, if these various propositions are taken as true on the strength of the demonstrations given, the reasoning is circular, because the demonstrations assume the axioms, but I mean more—I mean that any supposed *experimental* proof of these propositions, by measurement, itself assumes the axioms to be justified. For, even when the supposed experimental proof consists in showing that some two lines, demonstrated by reason to be equal, are equal when tested in perception, the axiom, that things which are equal to the same thing are equal to one another, is taken for granted. The equality of the two lines can be ascertained only by carrying from the one to the other some measure (either a movable marked line or the space between the points of compasses), and by assuming that the two lines are equal to one another, because they are severally equal to this measure. The ultimate truths of mathematics, then, cannot be established by any experimental proof that the deductions from them are true; since the supposed experimental proof takes them for granted. The same thing holds of ultimate physical truths. For the alleged *a posteriori* proof of these truths has a vice exactly analogous to the vice I have just indicated. Every evidence yielded by astronomy, that the axioms called "the laws of motion" are true, resolves itself into a fulfilled prevision that some celestial body or bodies will be seen in a specified place, or in specified places, in the heavens, at some assigned time. Now, the day, hour, and minute, of this verifying observation can be fixed only on the assumption that the Earth's motion in its orbit and its motion round its axis continue undiminished. Mark, then, the parallelism. One who chose to deny that things which are equal to the same thing are equal to one another, could never have it proved to him by showing the truth of deduced propositions; since the testing process would in every case assume that which he denied. Similarly, one who refused to admit that motion, uninterfered with, continues in the same straight line at the same velocity, could not have it proved to him by the fulfillment of an astronomical prediction; because he would say that both the spectator's position in space and the position of the event in time were those alleged only if the Earth's motions of translation and rotation were undiminished, which was the very thing he called in question. Evidently such a skeptic might object that the seeming fulfillment of the prediction, say a transit of Venus, may be effected by various combinations of the changing positions of Venus, of the Earth, and of the spectator on the Earth. The appearances may occur as anticipated, though Venus is at some other place than the calculated one; provided the Earth also is at some other place, and the spectator's position on the Earth is different. And, if the first law of motion is not assumed, it must be admitted that the Earth and the spectator *may* occupy these other places at the predicted time: supposing that, in the absence of the first law, this predicted time can be ascertained, which it cannot. Thus the testing process inevitably begs the question.

That the perfect congruity of all astronomical observations with all deductions from "the laws of motion" gives coherence to this group of intuitions and perceptions, and so furnishes a warrant for the entire aggregate of them which it would not have were any of them at variance, is unquestionable. But it does not therefore follow that astronomical observations can furnish a test for *each individual assumption*, out of the many which are simultaneously made. I will not dwell on the fact that the process of verification assumes the validity of the assumptions on which acts of reasoning proceed; for the reply may be that these are shown to be valid apart from astronomy. Nor will I insist that the assumptions underlying mathematical inferences, geometrical and numerical, are involved; since it may be said that these are justifiable separately by our terrestrial experiences. But, passing over all else that is taken for granted, it suffices to point out that, in making every astronomical prediction, the three laws of motion and the law of gravitation are *all* assumed; that, if the first law of motion is to be held proved by the fulfillment of the prediction, it can be so only by taking for granted that the two other laws of motion and the law of gravitation are true; and that non-fulfillment of the prediction would not disprove the first law of motion, since the error might be in one or other of the three remaining assumptions. Similarly with the second law: the astronomical proof of it depends on the truth of the accompanying assumptions. So that the warrants for the assumptions A, B, C, and D, are respectively such that A, B, and C, being taken as trustworthy, prove the validity of D; D being thus proved valid, joins C, and B, in giving a character to A; and so throughout. The result is that every thing comes out right if they happen to be all true; but, if one of them is false, it may destroy the characters of the other three, though these are in reality exact. Clearly, then, astronomical prediction and observation can never test any one of the premises by itself. They can only justify the entire aggregate of premises, mathematical and physical, joined with the entire aggregate of reasoning processes leading from premises to conclusions.

I now recall the reviewer's "thought," uttered in his habitual manner, "that every tolerably educated man was aware that the proof of a scientific law *consisted in* showing that, *by* assuming its truth, we could explain the observed phenomena." Having from the point of view of ordinary logic dealt with this theory of proof as applied by the reviewer, I proceed to deal with it from the point of view of transcendental logic, as I have to charge the reviewer with either being ignorant of, or else deliberately ignoring, a cardinal doctrine of the System of Philosophy he professes to review—a doctrine set forth not in those four volumes of it which he seems never to have looked into, but in the one volume of it he has partially dealt with. For this principle which, in respect to scientific beliefs, he enunciates for my instruction, is one which, in "First Principles," I have enunciated in respect to all beliefs whatever. In the chapter on the "Data of Philosophy," where I have inquired into the legitimacy of our modes of procedure, and where I have pointed out that there are certain ultimate conceptions without which the intellect can no more stir "than the body can stir without help of its limbs," I have inquired how their validity or invalidity is to be shown; and I have gone on to reply that—

"Those of them which are vital, or cannot be severed from the rest without mental dissolution, must be assumed as true *provisionally* . . . . leaving the assumption of their unquestionableness to be justified by the results.

"§40. How is it to be justified by the results? As any other assumption is justified—by ascertaining that all the conclusions deducible from it correspond with the facts as directly observed—by showing the agreement between the experiences it leads us to anticipate and the actual experiences. There is no mode of establishing the validity of any belief, except that of showing its entire congruity with all other beliefs."

Proceeding avowedly and rigorously on this principle, I have next inquired what is the fundamental *process* of thought by which this congruity is to be determined, and what is the fundamental *product* of thought yielded by this process. This fundamental product I have shown to be the coexistence of subject and object; and then, describing this as a postulate to be justified by "its subsequently-proved congruity with every result of experience, direct and indirect," I have gone on to say that "the two divisions of self and not-self are redivisible into certain most general forms, the reality of which Science, as well as Common-Sense, from moment to moment assumes." Nor is this all. Having thus assumed, *only provisionally*, this deepest of all intuitions, far transcending an axiom in self-evidence, I have, after drawing deductions occupying four volumes, deliberately gone back to the assumption ("Principles of Psychology," § 386). After quoting the passage in which the principle was laid down, and after reminding the reader that the deductions drawn had been found congruous with one another, I have pointed out that it still remained to ascertain whether this primordial assumption was congruous with all the deductions; and have thereupon proceeded, throughout eighteen chapters, to show the congruity. And yet, having the volumes before him in which this principle is set forth with a distinctness and acted upon with a deliberation which I believe are nowhere exceeded, the reviewer enunciates for my benefit this principle of which he "thought that every tolerably educated man was aware!" He enunciates it as applying to limited groups of beliefs to which it does not apply; and shuts his eyes to the fact that I have avowedly and systematically acted upon it in respect to the entire aggregate of our beliefs (axioms included) for which it furnishes the ultimate justification!

Here I must add another elucidatory statement, which would have been needless had the reviewer read that which he criticises. His argument proceeds throughout on the assumption that I understand *a priori* truths after the ancient manner, as truths independent of experience; and he shows this more than tacitly, where he "trusts" that he is "attacking one of the last attempts to deduce the laws of Nature from our inner consciousness." Manifestly, a leading thesis of one of the works he professes to review is entirely unknown to him—the thesis that forms of thought, and consequently the intuitions which those forms of thought involve, result entirely from the effects of experiences, organized and inherited. With the "Principles of Psychology" before him, not only does he seem unaware that it contains this doctrine, but, though this doctrine, set forth in its first edition published nearly twenty years ago, has gained considerable currency, he seems never to have heard of it. The implication of this doctrine is, not that the "laws of Nature" are deducible from "our inner consciousness," but that our consciousness has a preëstablished correspondence with such of those laws (simple, perpetually presented, and never negatived) as have, in the course of practically-infinite ancestral experiences, registered themselves in our nervous structure. Had he taken the trouble to acquaint himself with this doctrine, he would have learned that the intuitions of axiomatic truths are regarded by me as latent in the inherited brain, just as bodily reflex actions are latent in the inherited nervous centres of a lower order; that such latent intuitions are made potentially more distinct by the greater definiteness of structure due to individual action and culture; and that thus, axiomatic truths, having a warrant entirely *a posteriori* for the race, have for the individual a warrant which, substantially *a priori*, is made complete *a posteriori.* And he would then have learned that, as, during evolution, Thought has been moulded into increasing correspondence with Things, and as such correspondence, tolerably complete in respect of the simple, ever-present, and invariable relations, as those of space, has made considerable advance in respect of the primary dynamical relations, the assertion that the resulting intuitions are authoritative is the assertion that the simplest uniformities of Nature, as experienced throughout an immeasurable past, are better known than they are as experienced during an individual life. All which conceptions, however, being, as it seems, unheard of by the reviewer, he regards my trust in these primordial intuitions as like that of the Ptolemists in their fancies about perfection!

Thus far my chief antagonists, passive, if not active, have been Prof. Tait and, by implication, Sir William Thomson, his coadjutor in the work quoted against me—men of standing, and the last of them of world-wide reputation as a mathematician and physicist. Partly because the opinions of such men demand attention, I have dealt with the questions raised at some length; and partly, also, because the origin and consequent warrant of physical axioms are questions of general and permanent interest. The reviewer, who, by citing against me these authorities, has gained for some of his criticisms consideration they would otherwise not deserve, I must, in respect of his other criticisms, deal with very briefly. Because, for reasons sufficiently indicated, I did not assail sundry of his statements, he has reiterated them as unassailable. I will here add no more than is needful to show how groundless is his assumption.

What the reviewer says on the metaphysical aspects of the propositions we distinguish as physical, need not detain us long. His account of my exposition of "Ultimate Scientific Ideas," he closes by saying of me that "he is not content with less than showing that all our fundamental conceptions are inconceivable." Whether the reviewer knows what he means by an inconceivable conception, I cannot tell. It will suffice to say that I have attempted no such remarkable feat as that described. My attempt has been to show that objective activities, together with their objective forms, are inconceivable by us—that such symbolic conceptions of them as we frame, and are obliged to use, are proved, by the alternative contradictions which a final analysis of them discloses, to have no likeness to the realities. But the proposition that objective existence cannot be rendered in terms of subjective existence, the reviewer thinks adequately expressed by saying that "our fundamental conceptions" (subjective products) "are inconceivable" (cannot be framed by subjective processes)! Giving this as a sample from which may be judged his fitness for discussing these ultimate questions, I pass over his physico-metaphysical criticisms, and proceed at once to those which his special discipline may be assumed to render more worthy of attention.

Quoting a passage relative to the law that "all central forces vary inversely as the squares of the distances," he derides the assertion that "this law is not simply an empirical one, but one deducible mathematically from the relations of space—one of which the negation is inconceivable." Now, whether this statement can or cannot be fully justified, it has at any rate none of that absurdity alleged by the reviewer. When he puts the question: "Whence does he [do I] get this?" he invites the suspicion that his mind is not characterized by much excursiveness. It seems never to have occurred to him that, if rays like those of light radiate in straight lines from a centre, the number of them falling on any given area of a sphere described from that centre will diminish as the square of the distance increases, because the surfaces of spheres vary as the squares of their radii. For, if this has occurred to him, why does he ask whence I get the inference? The inference is so simple a one as naturally to be recognized by those whose thoughts go a little beyond their lessons in geometry.[1] If the reviewer means to ask whence I get the implied assumption that central forces act only in straight lines, I reply that this assumption has a warrant akin to that of Newton's first axiom, that a moving body will continue moving in a straight line, unless interfered with. For that the force exerted by one centre on another should act in a curved line, implies the conception of some second force, complicating the direct effect of the first. And, even could a central force be truly conceived as acting in lines not straight, the *average* distribution of its effects upon the inner surface of the surrounding sphere would still follow the same law. Thus, whether or not the law be accepted on *a priori* grounds, the assumed absurdity of representing it to have *a priori* grounds is not very obvious. Respecting this statement of mine, the reviewer goes on to say:

"This is a wisdom far higher than that possessed by the discoverer of the great law of attraction, who was led to consider it from no cogitations on the relations of space, but from observations of the movements of the planets; and

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[1] That I am certainly not singular in this view is shown to me, even while I write, by the just-issued work of Prof. Jevons on the "Principles of Science: a Treatise on Logic and Scientific Method." In vol. ii., p. 141, Prof. Jevons remarks respecting the law of variation of the attractive force, that it "is doubtless connected at this point with the primary properties of space itself, and is so far conformable to our necessary ideas."

who was so far from rising to that clearness of view of the truth of his great discovery, which is expressed by the phrase, 'its negation is inconceivable,' that he actually abandoned it for a time, because (through an error in his estimate of the earth's diameter) it did not seem fully to account for the motion of the moon."

To the first clause in this sentence, I have simply to give a direct denial; and to assert that neither Newton's "observations of the movements of the planets," nor other such observations continued by all astronomers for all time, would yield "the great law of attraction." Contrariwise, I contend that when the reviewer says, by implication, that Newton had no antecedent hypothesis respecting the cause of the planetary motions, he (the reviewer) is not only going beyond his possible knowledge, but he is asserting that which even a rudimentary acquaintance with the process of discovery might have shown him was impossible. Without framing, beforehand, the supposition that there was at work an attractive force varying inversely as the square of the distance, no such comparison of observations as that which led to the establishment of the theory of gravitation could have been made. On the second clause of the sentence, in which the reviewer volunteers for my benefit the information that Newton "actually abandoned" his hypothesis for a while because it did not bring out right results, I have first to tell him that, in an early number of the very periodical containing his article,[1] I cited this fact (using these same words) at a time when he was at school, or before he went there.[2] I have next to assert that this fact is irrelevant; and that Newton, while probably seeing it to be a necessary implication of geometrical laws that central forces vary inversely as the squares of the distances, did not see it to be a necessary implication of any laws, geometrical or dynamical, that there exists a force by which the celestial bodies affect one another; and therefore doubtless saw that there was no *a priori* warrant for the doctrine of gravitation. The reviewer, however, aiming to substitute for my "confused notions" his own clear ones, wishes me to identify the proposition—Central forces vary inversely as the squares of the distances—with the proposition—There is a cosmical force which varies inversely as the squares of the distances. But I decline to identify them; and I suspect that a considerable distinction between them was recognized by Newton. Lastly, apart from all this, I have to point out that, even had Newton thought the existence of an attractive force throughout space was an *a priori* truth, as well as the law of variation of such a force if it existed, he would still, naturally enough, pause before asserting this law, when he found his deductions from it did not correspond with the facts. To

[1] *See* Essay on "The Genesis of Science," in the *British Quarterly Review* for July, 1854, p. 127.

[2] I do not say this at random. The reviewer, who has sought rather to make known than to conceal his identity, took his degree in 1868.

suppose otherwise, is to ascribe to him a rashness which no disciplined man of science could be guilty of.

See, then, the critical capacity variously exhibited in the space of a single sentence. The reviewer, quite erroneously, thinks that observations unguided by hypotheses suffice for physical discoveries. He seems unaware that, on *a priori* grounds, the law of the inverse square had been suspected as the law of some cosmical force, before Newton. He asserts, without warrant, that no such *a priori* conception preceded, in Newton's mind, his observations and calculations. He confounds the law of variation of a force with the existence of a force varying according to that law. And he concludes that Newton could have had no *a priori* conception of the law of variation, because he did not assert the existence of a force varying according to this law in defiance of the evidence as then presented to him!

Now that I have analyzed, with these results, the first of his criticisms, the reader will neither expect me to waste time in similarly dealing with the rest *seriatim*, nor will he wish to have his own time occupied in following the analysis. To the evidence thus furnished of the reviewer's fitness for the task he undertakes, it will suffice if I add an illustration or two of the *animus* which leads him to make grave imputations on trivial grounds, and to ignore the evidence which contradicts his interpretations.

Because I have spoken of a balanced system, like that formed by the sun and planets, as having the "peculiarity, that though the constituents of the system have relative movements, the system, as a whole, has no movement," he unhesitatingly assumes me to be unaware that, in a system of bodies whose movements are not balanced, it is equally true that the centre of gravity remains constant. Ignorance of a general principle in dynamics is alleged against me solely because of this colloquial use of the word "peculiarity," where I should have used a word (and there is no word perfectly fit) free from the implication of exclusiveness. If the reviewer were to assert that arrogance is a "peculiarity" of critics; and if I were thereupon to charge him with entire ignorance of mankind, many of whom besides critics are arrogant, he would rightly say that my conclusion was a very large one to draw from so small a premise.

To this example of strained inference I will join an example of what seems like deliberate misconstruction. From one of my essays (not among the works he professes to deal with) the reviewer, to strengthen his attack, brings a strange mistake; which, even without inquiry, any fair-minded reader would see must be an oversight. A statement true of a single body acted on by a tractive force, I have inadvertently pluralized; being so possessed by another aspect of the question, as to overlook the obvious fact that with a plurality of bodies the statement became untrue. Not only, however, does the reviewer ignore various evidences furnished by the works before him, that I could not really think what I had there said, but he ignores a direct contradiction contained in the paragraph succeeding that from which he quotes. So that the case stands thus: On two adjacent pages I have made two opposite statements, both of which I cannot be supposed to believe. One of them is right; and this the reviewer assumes I do not believe. One of them is glaringly wrong; and this the reviewer assumes I do believe. Why he made this choice no one who reads his criticism will fail to see.

Even had his judgments more authority than is given to them by his mathematical honors, this brief characterization would, I think, suffice. Perhaps already, in rebutting the assumption that I did not answer his allegations because they were unanswerable, I have ascribed to them an unmerited importance. For the rest, suggesting that their value may be measured by the value of that above dealt with as a sample, I leave them to be answered by the works they are directed against.

Here I end. The foregoing pages, while serving, I think, the more important purpose of making clearer the relations of physical axioms to physical knowledge, incidentally justify the assertion that the reviewer's charges of fallacious reasoning and ignorance of the nature of proof recoil on himself. When, in his confident way, he undertakes to teach me the nature of our warrant for scientific beliefs, ignoring absolutely the inquiry contained in "Principles of Psychology," concerning the relative values of direct intuitions and reasoned conclusions, he lays himself open to a sarcasm which is sufficiently obvious. And when a certain ultimate principle of justification for our beliefs, set forth and acted upon in the "System of Synthetic Philosophy" more distinctly than in any other work, is enunciated by him for my instruction, as one which he "thought that every tolerably educated man was aware" of, his course is one for which I find no fit epithet in the vocabulary I permit myself to use. That in some cases he has shown eagerness to found charges on misinterpretations little less than deliberate, has been sufficiently shown; as also that, in other cases, his own failure to discriminate is made the ground for ascribing to me beliefs that are manifestly untenable. Save in the single case of a statement respecting collisions of bodies, made by me without the needful qualification, I am not aware of any errors he detects, except errors of oversight or those arising from imperfect expression and inadequate exposition. When he unhesitatingly puts the worst constructions on these, it cannot be because his own exactness is such that no other constructions occur to him; for he displays an unusual capacity for inadvertencies, and must have had many experiences showing him how much he might be wronged by illiberal interpretations of them. One who in twenty-three professed extracts makes fifteen mistakes—words omitted, or added, or substituted—should not need reminding how largely mere oversight may raise suspicion of something worse. One who shows his notions of accurate statement by asserting that, as I substitute "persistence" for "conservation," I therefore identify Persistence of *Force* with Conservation of *Energy*, and debits me with the resulting incongruities—one who, in pursuance of this error, confounds a special principle with the general principle it is said to imply, and thereupon describes a wider principle as being included in a narrower (p. 481)—one who speaks of our "inner consciousness" (p. 488), so asserting, by implication, that we have an outer consciousness—one who talks of an inconceivable conception; ought surely to be aware how readily lax expressions may be turned into proofs of absurd opinions. And one who, in the space of a few pages, falls into so many solecisms, ought to be vividly conscious that a whole volume thus written would furnish multitudinous statements from which a critic, moved by a spirit like his own, might evolve abundant absurdities; supplying ample occasion for blazoning the tops of pages with insulting words.

MORE ABOUT THE GRAPE-VINE PEST.

By CHARLES V. RILEY, M.A., Ph.D.

THE number of true (grape-vine) species of *Vitis*, with the cohering petals falling off when the flower opens, and bearing edible fruit, in the territory of the United States, is limited to nine. Of these, four species, viz., *Vitis Labrusca*, or Northern Fox; *Vitis æstivalis*, summer grape; *Vitis riparia*, river-bank grape; and *Vitis vulpina*, Southern Fox or Muscadine, are of chief practical consequence as having yielded our different cultivated varieties.

I will now proceed to indicate the relative susceptibility to the disease of the cultivated species and varieties. For the sake of conciseness, it will be best to indicate this susceptibility by letters and numerals, as follows:

0—No perfect leaf-galls found; or not at all subject to them.
a—Leaf-galls very rarely found.
b—Leaf-galls not unfrequently found.
c—Leaf-galls abundantly found, or very much subject to them.

0—Entirely free from root-lice.
1—Having the root-lice in unusually small numbers, but countervailing their punctures.
2—Root-lice often numerous; vines sometimes suffering from their effects.
3—Most subject to the root-lice and dying from their attacks whenever the conditions are favorable to their increase.

European Grape (*vinifera*), 0, 3.—The very few exceptions, where galls have been found on the leaves of this species, will scarcely invalidate the rule that it is free from galls. So likewise the few exceptional instances of the successful out-door growth of this in Missouri, which have come to my notice, and which it is unnecessary to detail here, do not affect the rule, and only prove that such vines can be grown outdoors when not destroyed by Phylloxera.

RIVER-BANK GRAPE (*riparia*).—ALVEY, *a*, 2; CORNUCOPIA (hybrid with *vinifera*), 0, 2; CLINTON, *c*, 1, where the leaf-galls are very abundant, the root-lice are generally less so, and *vice versa*. The roots have such vitality that disorganization does not always seem to follow the puncture of the louse, and new rootlets put out from the swellings with great vigor and thrift; DELAWARE, *b*, 2; GOLDEN CLINTON, *a*, 1; LOUISIANA (some say a seedling of *vinifera*; others, again, believe it *æstivalis*), *a*, 1; MARION, *b*, 1; OTHELLO (hybrid with *vinifera*), *a*, 2; TAYLOR, *c*, 1, much as with Clinton.

SUMMER GRAPE (*æstivalis*).—HERBEMONT, *a*, 1; CUNNINGHAM, 0, 1; CYNTHIANA, *a*, 1; NORTON'S VIRGINIA, 0, 1; RULANDER, 0, 1; TELEGRAPH, 0, 1.

NORTHERN FOX (*Labrusca*).—CATAWBA, 0, 3, suffering almost as badly as the varieties of *vinifera*; CHALLENGE (hybrid with *vinifera*), 0, 1; CREVELING, *a*, 2; CONCORD, *a*, 1; DIANA, 0, 2; DRACUT Amber, 0, 1; GOETHE (hybrid with *vinifera*), 0, 2; HARTFORD, 0, 2; IONA, 0, 3; ISABELLA, or seedlings thereof, 0, 2; ISRAELLA, 0, 1; IVES, 0, 2; MARTHA, 0, 1; NORTHERN MUSCADINE, 0, 1; REBECCA, 0, 2; SALEM, 0, 2; WILDER (hybrid with *vinifera*), 0, 1.

SOUTHERN FOX (*vulpina*), 0, 0.—From the investigations of Prof. Planchon, it results, as was anticipated from the great differences in character which it presents, compared with the others, that this species is entirely free from the Phylloxera in any form. The root is not only very tough, but has a perceptibly bitter taste, which doubtless renders it obnoxious to the insect. Prof. Planchon examined it thoroughly in North Carolina, where other vines in the vicinity were suffering from the insect.

From the above enumeration we may gather that, with the exception of *vulpina*, no species of cultivated vine is entirely free from the attacks of either the gall-making or root-inhabiting types. Nevertheless *vinifera* is least and *riparia* most subject to the former; *æstivalis* least, and *vinifera* most subject to the latter.

Of *vinifera*, a few varieties, under certain conditions, seem to exhibit a power of resistance in this country; and it is singular that some relative immunity has not as yet been noticed among the varieties of this species in Europe.

Of *riparia*, the Clinton, Taylor, Golden Clinton, and Marion, seem best to resist.

Of *æstivalis*, all the species enumerated resist well, and I would especially mention Norton's Virginia, Herbemont, and Cunningham, as vigorous growers.

Of *Labrusca*, the Concord, Dracut Amber, Israella, Martha, North Carolina, and Wilder, resist well.

This enumeration is founded principally on the effects of Phylloxera in the central portion of Missouri, as ascertained by quite extensive notes and observations made during the past two years. I have also examined many of the varieties mentioned, with similar results, in portions of Kansas, Illinois, New Jersey, Pennsylvania, and New York. The Arnold's hybrids, so far examined, all suffer; but some of them more than others.

Prophylactic Means of coping with the Disease.—It occurred to me that, by grafting the more susceptible on to the roots of the more resistant varieties, we might in a great measure counteract the disease, even if all other remedies failed. In the grape-growing districts of France, where the disease is so sweeping, and where the grape is so exclusively grown that its failure affects whole communities, the people may be obliged and can afford to go to much labor and expense in the use of insecticides to save their vines. Such insecticides may also be used in this country where it is desired to save a few choice vines regardless of expense and time. But I greatly fear that no direct remedy for such an underground enemy will ever be discovered, that will not entail too much labor and expense to be used, to any great extent, by our own grape-growers. These will either prefer to confine their attention to varieties which resist the enemy, or abandon the business entirely. Yet, if it shall once be demonstrated that varieties which now fail may be grown when grafted on to those which resist, I see no reason why it should not become as much a custom and a maxim among grape-growers to use some other vine as stock for such varieties as the Catawba, for instance, as it already is among pear-growers to use the quince, or among cherry-growers to use Mahaleb, Mazard, or Morello, as stocks.

In the course of a year or two we shall be able to fairly judge of the efficacy of the plan; for, aside from the trials that I am making in this country, others are being made on an extensive scale in France. Quite a number of plants for the purpose of experiment were sent over there from this country in the spring of 1872; and the demand has now become so great that a single firm, Isidor Bush & Co., of St. Louis, has this winter received orders for about four hundred thousand cuttings to be consigned to one place, Montpellier, and consisting of such varieties as have been recommended by myself and Prof. Planchon, as best resisting the disease. There is every reason to hope for the best results from these importations, as those vines, such as Herbemont, Cunningham, Concord, Clinton, etc., which best resist here, and which were planted there in 1871 and 1872 in Phylloxera-infested districts, have, thus far, done surprisingly well, as MM. J. Leenhardt, Pomier, V. Pulliat, and others, testify. Experience, so far as had in America, also promises the best results.

We have seen that the Southern Fox (*vulpina*) is the only species that is totally exempt from both leaf and root lice. This species is of no value whatever in the latitude of St. Louis, and does not flourish above latitude 35°. It cannot, therefore, be made of any avail here, and it is doubtful whether, in the blighted French vineyards, they will be able to profit much by its immunity. I fear that it will hardly flourish even in the extreme southern portion of that country; while the great difference between its wood and that of the other cultivated species must render it difficult to successfully graft these upon it.

Other Preventive Measures.—In planting a new vineyard the greatest care should be taken not to introduce the Phylloxera on the young plants; and a bath of weak lye or strong soap-suds before planting will, perhaps, prove the best safeguard.

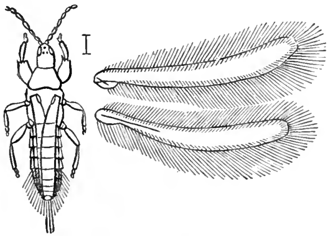
Remembering that the lice are spreading over the ground from July till fall, and principally in the months of August and September, a thorough sprinkling of the surface at this season with lime, ashes, sulphur, salt, or other substance destructive to insect-life, will no doubt have a beneficial effect in reducing their numbers and preventing their spread.

The insect has been found to thrive less, and to be, therefore, less injurious, in a sandy soil; while a mixture of soot with the soil has had a beneficial effect in destroying the pest. I have therefore recommended, for the more susceptible varieties, that they be planted in trenches, first prepared with a mixture of sand and soot: an addition of lime and ashes will also prove beneficial. There is every reason to believe that vines are rendered less susceptible to the disease by a system of pruning and training that will produce long canes and give them as nearly as possible their natural growth. Numerous instances are on record, and have come under my notice, of thrifty vines grown upon trees, or upon houses, with scarcely any pruning, and generally in firm, compact soil; while in the same neighborhood the same kinds of vines, in open culture, have been sickly or have failed.

Natural Enemies.—There are a number of different predaceous insects which serve to keep the leaf-lice in check; but, as the injury is mostly done underground, it will suffice to enumerate the principal of these in this connection. The most efficient is a black species of fringe-wing, or thrips, with white wings (*Thrips phylloxeræ* of my MS.). The egg, which is thrice as large as that of the louse, ellipsoidal and with a faceted surface, is deposited within the gall among the more legitimate inhabitants; and the young Thrips, which differ from their parents not only in lacking wings, but in being of a blood-red color, with only the extremities and the members black, play havoc with the lice. They are active, supple creatures, and turn up menacingly the posterior part of the body when disturbed. They are found in several different kinds of Phylloxera-galls, and do more than any other species to keep the leaf-inhabiting grape Phylloxera within bounds.

The next most efficient aid in the destruction of the leaf-lice is found among the lace-wing flies, one species of which, more especially, viz., the Weeping Lace-wing (*Chrysopa plorabunda* Fitch), I find very frequently within the galls, devouring their contents. These

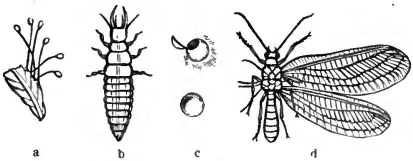
Fig. 1.



Thrips.

flies are known as well by their brilliantly golden eyes as by the peculiarly offensive odor, as of human ordure, which some of them emit. The eggs are adroitly deposited (Fig. 2, *a*) by the parent at the tips of long silk-like stalks, in order to prevent first-born larvæ from exer-

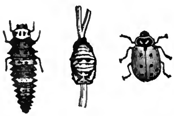
Fig. 2.



Lace-wing Fly.—*a*, eggs; *b*, larva; *c*, cocoon; *d*, fly, the wings to the left omitted.

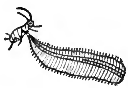
cising their cannibalistic propensities on their yet unborn brethren. The larva (Fig. 2, *b*) is very rapacious, and, when ready to transform, winds itself up into a wonderfully small cocoon (considering the size of the insect which makes it and which issues from it), which is spun

Fig. 3.



Convergent Ladybird; a larva, pupa, and beetle.

Fig. 4.



Syrphus Larva.

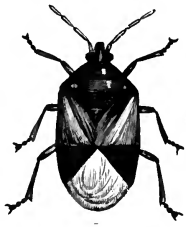
from the extremity of the body, and from which it issues, when about to acquire wings, through a neatly-cut, circular aperture. Next in order, as Phylloxera enemies, may be mentioned the Ladybirds (*Cocci-*

nella), especially certain small dark-brown species belonging to the genus *Scymnus*, and whose young, thickly covered with white and evenly-shorn tufts of a cottony secretion, are frequently found at their good work within the galls. Following these may be mentioned, as auxiliaries, certain Syrphus-fly larvæ, which, being blind, go groping about among the eggs and young lice, which they seize and suck to

Fig. 5.

Syrphus Fly.

Fig. 6.

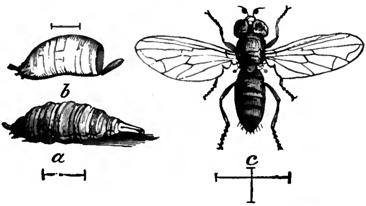


Insidious Flower-Bug.

death. Also certain orange larvæ of a smaller two-winged fly (*Leucopis*); a few genuine bugs (*Heteroptera*), and notably the Insidious Flower-bug (*Anthocoris insidiosus*, Say, Fig. 6), and certain smaller Hymenopterous parasites.

The enemies known to attack the Phylloxera underground are, naturally enough, fewer in number. In one instance I have found a Scymnus larva at the work six inches below the surface, and there is a Syrphus fly (*Pipiza radicum*, W. and R., Fig. 7) whose larva lies underground and feeds both on the apple-tree-root louse, and on this

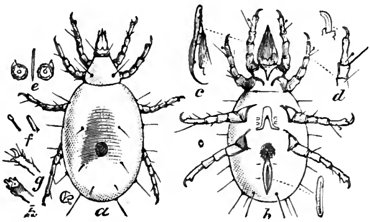
Fig. 7.



Root-louse Syrphus Fly.—*a*, larva; *b*, pupa; *c*, fly.

grape-root louse. Wonderful indeed is the instinct which teaches the blind larva to penetrate the soil in search of its prey; for the egg must necessarily be laid at the surface. But, though the underground enemies of its own class are few, I have discovered a mite which preys upon this root-inhabiting type, and which renders efficient aid in keeping it in check in this country. This mite (*Tyroglyphus phylloxeræ* Planchon and Riley, Fig. 8) belongs to the same genus as the cheese and meal mites (*T. zivo*, Linn.), and the species (*T. entomophagus* Laboulbène) which infests preserved insects, and is such a pest in cabinets.

Fig. 8.



Phylloxera Mite.—*a*, dorsal; *b*, ventral view of female; *c*, mouth-parts magnified; *d*, *f*, *g*, *h*, forms of tarsal appendages; *e*, ventral tubercles of male.

Direct Remedies.—The leaf-lice, which do not play such an important part in the disease as was at first supposed, may be controlled with sufficient ease by a little care in destroying the first galls which appear, and in pruning and destroying the terminal growth of infested vines later in the season. The root-lice are not so easily reached. As the effort will be according to the exigency, we may very naturally look to France for a direct remedy, if ever one be discovered. But, of all the innumerable plans, patented or non-patented, that have been proposed, of all the many substances that have been experimented with, under the stimulus of a large national reward, no remedy has yet been discovered which gives entire satisfaction, or is applicable to all conditions of soil. Nor is it likely that such a remedy ever will be discovered. A large majority of the remedies proposed, such as the planting of *Madia sativa* among the vines, or inoculating them with the essence of *Eucalyptus globulus*, are, upon their face, absurd. These we will pass by, and briefly mention only those which have been more or less productive of good.

Submersion, where practicable, and where it is total and sufficiently prolonged, is a perfect remedy. This is what even the closet-student might expect, as he finds that excessive moisture is very disastrous to the lice. M. Louis Foucon, of Graveson (Bouches-du-Rhône), France, has abundantly proved its efficacy, and has, by means of it, totally annihilated the insect from his vineyard, which was suffering from it four years ago. From his experience we may draw the following conclusions: 1. The best season to submerge is in autumn (September and October), when the lice are yet active, and the vines have ceased growing. Submergence for twenty-five to thirty days, at this season, will generally rout the lice. 2. A submergence of forty to fifty days in winter is required, and even where the water is allowed to remain during the whole of this season the vineyard does not suffer. 3. A vineyard should never be inundated for a longer period than two days in summer, or during growth; and though these brief inundations at that season affect only the few lice near the surface, and are by no means essential, they are nevertheless important auxiliaries to the more thorough fall or winter submersion, as they destroy the few lice which are always invading a vineyard in infested districts. These summer inundations will be necessary only after the winged insects begin to appear; and three or four, each lasting less than two days, made between the middle of July and the fall of the leaf, will effect the end desired. 4. An embankment should be made around the vineyard, in order that the water may evaporate and permeate the earth, but not run off and carry away any nutritive properties of the soil.

The varied success which has attended the different attempts to rout the enemy by inundation, is owing to the lack of thoroughness in many of them. The ground must be thoroughly soaked for a sufficient length of time. Temporary irrigation does not accomplish the end, for the reason that it does not reach all the lice, and does not break up the numerous air-bubbles which form in the soil, and prevent the drowning of many of the insects.

On our best hilly vine-land thorough submersion is impracticable, but on our bottom-lands some of the grapes, which fail now, may be made to succeed by its means.

Of 140 different applications made by an intelligent and competent commission in the department of Hérault, France, most of the pure insecticides proved valueless. Many of them, such as carbolic acid, oil of cade, arsenious acid, sulphide of calcium, sulphide of mercury, arseniate of potash, etc., etc., will effectually kill the insect when brought in direct contact with it; but, in field-practice, they can either not be brought in this direct contact, or else cannot be used strong enough to kill all the lice without injuriously affecting the vine.

Carbolic acid added to water, at the rate of about one per cent., applied by pouring into deep holes, made by a crow-bar or auger, has given satisfactory results; and a thorough application of soot has also been strongly advocated by those who have tried it. In the experiments that I have been able to make, in a small way, a thorough mixing with the soil of a cheap carbolic powder, prepared by G. Mallinckrodt & Co., of St. Louis, has given good results.

The latest insecticide that has attracted attention and given great hopes in France is the bisulphide of carbon. It seems to have been used as early as 1869 by Baron Thenard, but was brought prominently before the public last autumn by Messrs. Monestier, Lautand, and D'Ortoman, who first proposed to introduce it at a great depth in the soil, so as to utilize its vapor. A vapor will naturally have the advantage over a liquid, as it will more effectually permeate the soil and reach the lice. The following is the method of procedure in their own words:

"Make three holes around the vine, the depth to vary according to nature of soil, but generally about 2½ feet (80 centimetres). Hitherto we have made these holes with a pointed iron bar, driven by a maul. When the hole is made the bar is withdrawn, and a tube, furnished with a funnel at one end, is inserted in its place. About two ounces of sulphuret of carbon are then poured into the tube, which is immediately corked. . . . The vapor of this sulphuret of carbon permeates the soil, and impregnates all the roots of the vine. The gas engendered is not, like the liquid itself, fatal to the vine, but invigorates it. Its effects are, however, sure death to the insect, and, if a vine is examined eight days after the treatment, the lice are found dead and carbonized. At the end of fifteen days nothing but the effects of the lice is seen. Long and corroborative experience has demonstrated that about four ounces (100 grammes) of the liquid is sufficient for an ordinary vine; but sprinkling on the surface must be carefully avoided, as it is then very injurious to the vine; whereas as much as a pound may be made to penetrate the soil without injury to the roots."

Soon after the announcement of this method, I employed it as a test on three vines, which I knew to be infested with Phylloxera, using three ounces to the first, six ounces to the second, and nine ounces to the third, the soil being a light clayey loam. At the end of twelve days I found plenty of living lice on the first and second vines, and such were found long afterward, though in small numbers, up to the time of the freezing of the ground. On the third vine all the lice were evidently charred, but the vine was also plainly injured, as the leaves wilted as though they had been scorched, though, whether from the vapor issuing from the ground, or from the injury to the root, it was impossible to determine—I think, however, from the former, as the larger roots were yet alive late in the season, and the vine seems, at this writing, to be living.

After very careful and laborious experiments made in France at different points, and on different kinds of soil, by a commission specially charged with studying the action of this chemical, under the method proposed by Messrs. Monestier, Lautand, and D'Ortoman, it fails to fulfill the sanguine expectations of these gentlemen. The liquid is costly, its application is laborious, and there is great difficulty in reaching and killing all the lice without injuring the vine. Great caution must also be had in its use, as it is extremely volatile and explosive, the vapor igniting at a great distance from the vessel containing it.

While, therefore, not very satisfactory results have followed the use of pure insecticides, the application of fertilizers, intended to invigorate the vine, and at the same time injure the lice, has been more productive of good. Especially has this been the case with fertilizers rich in potassic salts and nitrogenous compounds, such as urine.

Sulphuret of potassium, dissolved in liquid manure; alkalino-sulphates, with copperas and rape-seed; potassic salts, with guano; soot and cinders, are, among other applications, most favorably mentioned.

RANGE OF THE INSECT IN AMERICA.—As already intimated, the insect is indigenous to the North American Continent. I have been able to trace its existence, with absolute certainty, as far back as 1834; for, in the herbarium of Dr. Engelmann, there are specimens of *Vitis monticola* (Buck) that were gathered that year in Texas by the botanist Berlandier, and which have Phylloxera galls upon the leaves; while specimens of *riparia* in the same collection, and gathered in Missouri in 1845, also have the leaves disfigured by the same gall.

We find, in consequence, that the insect is very generally distributed over the States. I have myself found it in Kansas, Iowa, Illinois, Missouri, Michigan, Ontario, New York, New Jersey, Pennsylvania, and Maryland, and have abundant evidence of its occurrence in Connecticut, District of Columbia, North Carolina, Texas, and as far south as Florida. It doubtless occurs in all the intermediate States. There is every reason to believe, however, that, like so many other animals which occur on the eastern slope of the Rocky Mountains, but are unknown on the western slope, this Phylloxera is not indigenous to the Pacific half of the continent. I have, so far, been unable to trace its existence with any certainty in California; and to its non-existence there the California grape-growers doubtless owe, in great part, their success in the cultivation of the European vine. Yet I have strong evidence that around Sonoma the insect already occurs, and has done much damage; and it may have been introduced either from the Eastern States or from Europe into other parts of that country. It, therefore, behooves our friends of the Golden State to carefully look into this matter, and to endeavor, by taking the proper precautionary steps, to prevent a repetition of the disasters which have followed the introduction and spread of Phylloxera in Europe.

INJURY CAUSED BY PHYLLOXERA IN AMERICA.—In this country, where, compared with Europe, land is so rich and abundant, we are apt to think lightly of injury to our crops, except when such injury becomes very great and wide-spread. It is a fact, long ago remarked by Dr. Fitch, State Entomologist of New York, that while in Europe the whole people become alarmed if a fifth of a given crop is destroyed by insects, the farmer here often thinks himself fortunate if he can save half the average yield from insect depredations. Vines have died year after year in our vineyards, and very little notice has been taken of the fact; while certain varieties have continually failed until they have come to be discarded as unprofitable and useless. Yet the day is fast coming when the growing of superior varieties, which have for the most part failed, will alone be remunerative; and I believe that nothing will so tend to enable us to successfully grow them as a thorough knowledge of Phylloxera, which is, in reality, the principal cause of their failure. Take as an instance the case of the Catawba. It is in growing demand in the Mississippi Valley, as, so far, the best white-wine grape, and the only one extensively used in the manufacture of sparkling wines. Yet it is, in this part of the country, one of the most susceptible to the Phylloxera disease, and its successful growth becomes more and more uncertain. If by a thorough understanding of the disease, and by the system of grafting which I have suggested, this vine can be successfully grown in the Mississippi Valley, it is safe to say that the value of our vineyards will be doubled; as the Concord, which is now the main reliance, and which makes but an inferior wine, has already so glutted our markets as scarcely to pay the grower.

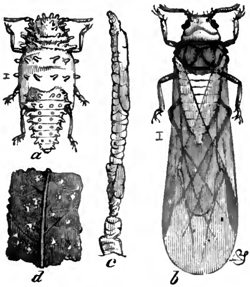
Why the Insect is more injurious in Europe than in America. —Without going into particulars, several good reasons may be given to explain the fact that Phylloxera is more devastating in the vineyards of France than in our own. There exists a certain harmony between the indigenous fauna and flora of a country, and our native vines are such as from their inherent peculiarities have best withstood the attacks of the insect. The European vine, on the contrary, succumbs more readily, not only because of its more tender and delicate nature, but because it has not been accustomed to the disease —there being, doubtless, a parallel between this case and the well-known fact that diseases and parasites which are comparatively harmless among peoples long accustomed to them, become virulent and often fatal when first introduced among hitherto uncontaminated peoples.

Then the particular natural enemies of the insect which belong to its own class, and which in this country help to keep it within due bounds, are lacking in Europe; and it will require some time before the closely allied European predaceous species will prey upon and check it there to the same extent.

The Phylloxera will, also, other things being equal, have an advantage in those countries where the mildness and shortness of the winter allow an increase in the annual number of its generations. Finally, the differences in soil and in modes of culture have no insignificant bearing on the question in hand. Though Phylloxera, in both types, is found on our wild vines, it is very doubtful if such wild vines, in a state of nature, are ever killed by it. With their far-reaching arms embracing shrub and tree, their climbing habit unchecked by the pruner's knife; these vines have a corresponding length and depth of root, which render them less susceptible to injury from an underground enemy. Our own method of growing on trellis approaches more nearly these natural conditions than that employed in the ravaged French districts, where the vines are grown in greater proximity and allowed to trail on the ground, or are supported by a single stake.

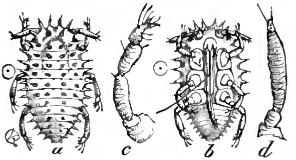
THE AMERICAN OAK PHYLLOXERA (*Phylloxera Rileyi*).—There are several described and undescribed species of Phylloxera in this country, most of them inhabiting leaf-galls made on our different hickories. The species herewith figured is the only external feeder known in America, and it is briefly alluded to in this connection to show that, as with the grape Phylloxera, it does not need a "winter egg" to enable it to hibernate, but passes the winter in the larva state (as at

FIG. 9.



PHYLLOXERA RILEYI.—*a*, pupa; *b*, winged female; *c*, antenna greatly enlarged; *d*, portion of infested leaf.

FIG. 10.



PHYLLOXERA RILEYI.—*a*, *b*, dorsal and ventral views of larva as seen hibernating; *c*, *d*, highly-magnified leg and antenna of same.

Fig. 9), firmly attached to the tender bark of the younger twigs, and thus braving all the vicissitudes and inclemencies of that season. In the summer it is found on the underside of the leaves of our white and post oaks, fixed in the centre of a yellowish spot caused by its puncture, and showing most on the upper surface, so that on a badly-infested tree the leaves all look speckled, and seared, and withered. It presents all the different forms and the same biological characteristics that I have described and detailed of the grape Phylloxera.

CONCLUSION.

We have, in the history of the grape Phylloxera, the singular spectacle of an indigenous American insect being studied, and its workings understood in a foreign land, before its presence in its most injurious form was even suspected in its native home. The Franco-Prussian War, with all its fearful consequences to France, has passed away; the five milliard francs (one thousand million dollars) have been paid, as indemnity to her victors, in so short a time that the civilized world looked on in wonder and astonishment. Yet this little Phylloxera, sent out, doubtless, in small numbers, by some American nurseryman, a few years since, continues its devastating work, and costs that unfortunate country millions of francs annually. The last German has been removed from French soil—at terrible cost, it is true—but the Phylloxera army remains; and, if another five milliard francs could extirpate the last individual of this liliputian insect-host from her soil, *La belle* France would be cheaply rid of the enemy. Had the world, twenty years ago, possessed the knowledge we at present have of this insect and of its dangerous power, a few francs might have originally stayed its invasion of that great vine-growing and wine-making country. Needs there any more forcible illustration of the importance of economic entomology!

SCIENTIFIC AND INDUSTRIAL EDUCATION IN THE UNITED STATES.[1]

By ANDREW D. WHITE, LL. D.,
PRESIDENT OF CORNELL UNIVERSITY.

A LITTLE more than two hundred years ago, in England of the Roundheads and Cavaliers, a voice was raised to propose that young men receive instruction bearing on the various national industries. He who proposed this was a man of great genius—one of the true priests and prophets of his time. He foresaw and foretold many great modern inventions, and among them the steam-engine. His brain helped to think out its principles, his hands helped to shape its groundwork. With pen and tongue he sought to promote the "new education;" but he had fallen on evil times. With Strafford and Laud on one side, and Hampden and Cromwell on the other, there was but poor hearing for the industrial ideas of the Marquis of Worcester. Persecuted, maligned, and a bankrupt, he died, and, to all appearance, his idea died with him. For two centuries afterward Oxford and Cambridge solemnly ground out the old scholastic product in the old scholastic way.

About fifty years ago, a body of the best scholars and thinkers in England made another attempt. Their endeavor was, to found an institution giving an education fitted to the needs of their land and time. They established the University of London. Never had a plan more brilliant advocates. Brougham, Sydney Smith, and Macaulay, spoke and wrote for it; but their success was small. The institution was unsectarian, therefore the Church declared against it as "godless;" it gave instruction in modern learning as well as in ancient learning, therefore the great body of solemn scholars declared it unsound; some of its ideas and methods were new, therefore a multitude of leaders of society declared it unsafe. The institution was kept down, and from that day to this has never taken the high place to which its plan and work entitled it.

[1] An Address delivered before the New York State Agricultural Society, revised by the author for the POPULAR SCIENCE MONTHLY.

About thirty years since, the strongest man who has ever stood in an American college presidency made an effort in the same direction. Francis Wayland knew what there was of good in the old scholarship and was loyal to it, but he saw that new times make new demands, and he planned out and endeavored to work out a system of education which should meet these demands. All to no purpose. It was the old, old story—another great man, with his great idea, as Carlyle phrases it, "trampled under the hoofs of jackasses," or, as Wayland himself phrased it more mildly, "nibbled to death by ducks."

Various minor attempts were made—some of them, like Eaton's noble effort at Troy, very fruitful; but no general plan, no large institution was created worthy of the great interest involved.

About five years later, Mr. Lawrence, of Massachusetts, a thoughtful manufacturer, made another attempt. He saw the necessity of education bearing on the great industries of the country, and made to Harvard College what in those days was called a princely gift. Thus was founded the "Lawrence Scientific School," at Cambridge, and thus did industrial studies get their first foothold in a great university.

About five years later still, Mr. Sheffield, of Connecticut, also a thoughtful business-man, recognized this great necessity. By a generous donation he founded the "Sheffield Scientific School" at Yale College, and thus these studies got foothold at a second great university.

So much, then, was gained. Some few of the studies bearing on the great modern industries had been taken under the care of great university corporations; but there was one drawback. In neither of these universities were the new studies received into full fellowship with the old. The Scientific School was kept very distinct from the "College proper." Buildings, courses, and studies, were kept well apart; the student in the sciences was not considered the equal of the student in "the classics." The student preparing for an industrial profession was not considered as of the same caste with the student preparing for a "learned profession." He lived in a different building, had lectures and recitations in different rooms, was instructed by different professors, was graduated at a different time and place. He was not considered as properly of the graduating class of his year. Ask any Yale or Harvard man for the names of his classmates, and it never occurs to him to mention the graduates of his year from the scientific departments. Nay, whether it was that young men taking scientific studies were considered as *ipso facto* lost souls, or as having no souls to be saved at all, they were not admitted to the students' seats at the college chapel—they were practically held as of an inferior order.

The next step was made at the State University of Michigan. Here, for the first time in a university, a student in general or industrial science was admitted to full equality with a student in classics.

So far as their studies were the same, they sat in the same rooms, heard the same lectures from the same professors, were admitted to the same chapel, received their degrees at the same time and place, went through the same ceremonies, and stood as equals on the roll of graduates.

Still the provision for industrial education was wretchedly meagre. Other nations had meanwhile shot far ahead of our own in this respect. Germany, France, and even England, had been aroused. They had recognized the fact that the greatest warfare of the nineteenth century is industrial warfare—the struggle between great nations for supremacy in the various industries, and for the control of the various markets. France had developed magnificently her system, putting nearly half a million dollars into a collection of models for the School of Arts and Trades alone. Germany had established a multitude of "*Real Schulen*," and of Technical and Agricultural Colleges. England was already making preparations for her great institution at South Kensington, on which she has lavished millions.

But, just as our great rebellion was drawing on, an attempt was made in the Congress of the United States. Years before, that pure and great man, Dr. Channing, had urged that the proceeds of the sales of public lands be consecrated to the education of the people. An attempt was now made; but, though the good sense of Congress carried a bill, it was vetoed by James Buchanan. But the friends of the measure still pressed on. A chorus of optimists, pessimists, sham economists, holdbacks, and do-nothings, opposed the measure; but a true statesman led the army of education. Justin S. Morrill, of Vermont, stood then as now in the United States Senate. Let his name be long remembered. Statues shall be erected to him long after the little great men who tried to thwart him are forgotten. The bill was passed, and it was signed by Abraham Lincoln.

I ask you now to look a moment at the passage of that bill. Centuries hence men shall look back upon it as one of the noblest things in American annals. Why?

My friends, have you forgotten those days, their discouragements, their forebodings, the morning beginning with "would God it were evening," and the evening ending with "would God it were morning?" It was the darkest hour since Valley Forge; lives, laws, family ties, treasure—all seemed cast into the abyss—and the abyss ever growing wider, and deeper, and blacker—and yet, while the American Congress was providing for the most tremendous home policy, and carrying on the most difficult foreign policy of modern times, they found leisure to plan and carry out a great, comprehensive, and far-reaching system of national education.

Gentlemen, it was one of the great glories of Rome in its best days that its statesmen did not despair of the Republic in its blackest hours. Nay, when a victorious Carthaginian army was encamped on Roman soil, so great was Roman faith in Roman destiny, that the very soil at that moment trampled by enemies' feet was sold at auction and bought by competition. But here was greater faith; here was nobler patriotism. While the windows of the Senate-house were rattling with the enemy's cannon, those men had such faith in the destiny of the nation, and such trust in the arts of peace, that they quietly and firmly legislated into being this great, comprehensive system of industrial and scientific education. In all human annals I know of no more noble utterance of faith in national destiny out from the midst of national calamity.

But what was this measure?

The question is pertinent, and all the more so now, on account of sundry efforts to misrepresent it. Look at the act of Congress itself. You see at once that it did not provide simply for agricultural colleges, nor simply for colleges of the mechanic arts. No; the intention was broader and deeper than that. It provided that "subjects relating to agriculture and the mechanic arts" should be made "leading branches," "without excluding other classical and scientific branches," and including "military tactics."

What, then, was the purpose? It was to provide fully for an industrial, scientific, and general education suited to our land and time —an education in which scientific and industrial studies should be knit into its very core, while other studies should also be provided for. And, besides this, as it had been seen that the States in rebellion had gained great advantage from the military education of students, it was declared that "instruction in military tactics shall also be included."

The act of 1862 was, then, a noble, comprehensive scheme, looking, as you see, first of all, at the industries of the nation, but at the same time insisting on provision for the broadest scientific and general culture.

I pass now to the reception of the benefits of the act by the various States.

Under the law, land-scrip was given the different States, based upon the representation of each State in Congress, scrip for thirty thousand acres being issued for each representative and senator. You will note here, in passing, one more provision showing thoughtful statesmanship. It was provided that, except in the case of States having public lands within their own borders, *no State should "locate" the scrip.* The great majority of the States could not, therefore, obtain *land.* They could only take the scrip and sell it at market prices. An individual might buy the scrip and locate it; a State could not. Thus was prevented any troublesome *imperium in imperio*, such as would have been created, for example, had the State of New York been allowed to acquire a million of acres in the heart of the State of Wisconsin.

The various States accepted the scrip, and in almost all cases sold it at low prices, the market being glutted; and with the proceeds each established its institution under the act as its interests demanded, or as the money realized permitted.

Note now another important fact. Some States—as Connecticut, Rhode Island, and New Jersey, where the fund was too small to establish a separate institution—gave it for the endowment of scientific and industrial education in an existing institution. Connecticut gave her share to Yale, Rhode Island gave hers to Brown, New Jersey gave hers to Rutgers, New Hampshire gave hers to Dartmouth.

States which received a larger share—but still not enough to carry out the act in all its parts—gave theirs to purely agricultural colleges. Of these were Michigan and Iowa. Others, with a larger share, divided theirs between an institution for agricultural and an institution for technical instruction. Of these were Massachusetts and Missouri. A few which received the largest share determined to carry out the act in its whole scope by founding a single institution, in which industrial and scientific education should be united to general instruction and culture. Of these were Illinois and New York.

It may appear to some that this difference in modes of carrying out the act in the different States was a misfortune. Far from it. I am prepared to maintain, against all comers, that, of all the good fortune which has attended the carrying out of the act of 1862, this variety of plans and methods in the various States was the best.

Look at it for a moment. Of all men none has stamped more ideas into the thinking of this generation than has John Stuart Mill; but among all his thoughts regarding education I remember none more pregnant and original than one regarding systems of public education. It is that, with all its benefits, such a system has one great danger, and that is, its tendency to shape all minds by the same course of education into the same mould, thus preventing the fruitful collision and friction of mind with mind; thus bringing on a stagnant, barren sort of Chinese routine in thought.

Happily for us, by leaving these funds to each State for management, this evil has been avoided. And not only this, but almost every one of these institutions has found out something of use to every other. There is, indeed, unity between all, but not uniformity; and here let me say that having made it my business to look closely into the methods of all these institutions, and to visit and personally inspect many, in order to bring home what might be good for our own use, I can bear testimony that never have funds been more carefully applied and made to do more in furthering this great purpose.

I know every one of these institutions, and I know not one which is not making a noble return on all it has received.

No sooner was the bill passed than a multitude of colleges rushed forward to these legislative halls in a scramble for the fund. At one time there were twenty institutions calling themselves colleges and universities of various religious denominations clamoring at Albany for a scrap of this endowment. As scrip was selling, the whole fund, had not an individual come forward to "locate" it, would have amounted to about $600,000. Dividing this among the twenty, there would not have been enough money to give a single professorship to each.

This the Legislature of New York saw, and, despite the pressure from these institutions, it wisely determined not to fritter away the fund, but to concentrate it. It recognized the fact that for primary education the rule is diffusion of resources, but, for advanced education, concentration, and it wisely concentrated the fund upon an institution known as the People's College, at Havana.

The endowment was given to the People's College on certain conditions. Among them, it was required that the institution should have a certain amount of land, accommodations for a certain number of students, a Faculty of a certain size, a certain equipment, and that it should be free from incumbrance. A year went by, and these conditions were not complied with. Still the Legislature waited, and sturdily refused to yield to clamors for frittering away the fund. Another year went by, and still nothing was done; and, what was worse, it was discovered that a bill had been introduced to relieve the People's College of these conditions. At this, Mr. Ezra Cornell came forward and offered to pledge an endowment of $500,000 to a new institution, provided the funds were transferred to it. A bill was passed chartering such a new institution; but, in order that full justice might be done the People's College, it was allowed three months to put itself in possession of such sum as the Board of Regents of the State should declare equivalent to compliance with the conditions of the original act.

The Regents, after full examination, fixed the sum at less than $170,000. For nearly three years, then, that institution might have obtained the whole endowment had its friends, or had that locality, raised for it a sum of less than $170,000. The time passed—they still did nothing. Mr. Cornell then came forward and redeemed his pledge; and thus was founded, for scientific, industrial, and general education, the Cornell University.

So much for the main features of the struggle toward the establishment of what has been called the "New Education" in the United States and the State of New York.

But what is this new education? I ask you to look first at its special purpose, and finally at its general scope. And, first among the special departments grouping themselves under such a system, I name the College of Agriculture.

And here let me refer to a misapprehension, which should be corrected at the outset. For a typical example of this, I take up a paper read at the recent Educational Convention at Elmira, by the Rev. Dr.

McCosh, President of Princeton College. In that paper, the whole national and State policy regarding scientific and industrial education was condemned. The decision arrived at by two different Congresses of the United States, and by nearly thirty State Legislatures, the plan adopted by nearly thirty Boards of Trustees and Faculties in the various States—many of them after careful study of institutions at home and abroad—were dismissed with contempt. The main argument was, so far as argument can be detected among the multitude of assertions, that Scotland, from which the doctor had not long before emigrated, had got along well enough without any provision for agricultural instruction.

Never was there a more admirable illustration of the thoughts put forth by James Russell Lowell, on "a certain condescension in foreigners." To two institutions the doctor paid his respects by name, one being Rutgers College, in New Jersey; the other Cornell University. The first of these, Rutgers College, it would appear had committed an unpardonable sin. While the doctor's learned predecessors, at Princeton, had been preaching against "science falsely so called," the Rutgers College authorities had received that portion of the college land-grant fund which came to New Jersey, and had established an admirable school for applied science. This it was, doubtless, which led the doctor, in the heart of this State of ours which glories in its descent from the men who founded the Dutch Republic, to stigmatize his sister institution in New Jersey as "managed by a pack of Dutchmen."

His reference to the Cornell University was of another character, and not all my respect for the doctor's ability as a metaphysician will allow me here to suppress the fact that his whole argument was based upon one of the most astounding misrepresentations ever attempted upon an American audience.

This misrepresentation was in regard to the law of Congress of 1862. Throughout the doctor's address the idea is conveyed that the law of 1862 contemplated solely the establishment of exclusively agricultural colleges.

Nothing could be more wide of the fact. Had the doctor ever read that law he would have seen that, while "subjects relating to agriculture and the mechanic arts" were named as "leading branches," it was expressly declared in the act that other scientific and classical branches should not be excluded. Nay, more, he would have seen that so broad was the intention of Congress that the wording of the act is, that "subjects *relating* to agriculture and the mechanic arts" shall be taught, thus giving the authorities permission to extend their teaching into every field of learning which could strengthen these departments or elevate them.

I am aware that, in opposition to the plain intent of the act of 1862, the doctor may fall back upon its title, in which, for the sake of brevity, only the leading objects of the colleges are mentioned; but, had he read even so accessible an exposition of law as Kent's "Commentaries," he would have found that every act is to be construed by its contents and not by its title.

But the doctor was especially hilarious over the small number of graduates from our agricultural colleges.

Let us look at this. The number is at present very small, but I presume that no thoughtful man expected that at so early a period after their establishment the number would be very large, nor, indeed, do I expect that for some years the number will greatly increase. In a new country like ours, those professions which present the most brilliant returns will be sought for first. Hence we find that, when a farmer decides to educate his son, it is not generally with the idea of making him a farmer. And, even when he does bring him up as a farmer, he has great doubts as to the value of any instruction for that purpose outside of the old farm routine.

But while I allow freely that this is the case now, I can state quite as confidently that this condition of things cannot continue for many years. There are those now living among us who will stand among a hundred millions of citizens within the boundaries of our Republic. When that day comes—nay, long before—this present condition of things must change. The present system of routine cultivation—this present system of "skinning" lands and then running away to soils more fruitful, in the intention of robbing and running away from them in turn—cannot last. Men must get a subsistence on less and less land; and they can only get it by bringing to bear upon it better and better cultivation. How soon we shall come to the division of property in the Scotch Lothians or the Belgian Pays de Waes, with their small farms exquisitely tilled, and supporting well a body of thrifty men, I cannot say; but the steady approximation to it is as inevitable as fate. And at the same time that this goes on, the professions hitherto known as "learned" will be more and more thoroughly filled. We see the beginnings of this now. Already is it becoming less and less easy for the farmer's boy to be sure that the little dark office in the great city block, swarming with lawyers, is, after all, so much more promising than the open fields and the work of the farmer.

And now, what should this industrial education be? Many men, hastily looking over the subject, have jumped to the conclusion that it should consist in simply teaching the plain arts of husbandry and of mechanics; that is, that the great object should be to train young men simply or mainly to hoe or spade or plough in the fields, or to make chairs or shoes, or hats or boats, in the shops. There could be no more wretched perversion of the trust imposed by Congress. The phraseology of the act of 1862 was chosen with great care, and, when it speaks of "branches *relating* to agriculture and the mechanic arts," it means just what it says. It meant to provide that all applicable science be brought to bear on those arts. It meant to provide for the education of men who could develop them and improve them. Merely to add, to the millions now intelligently practising these arts, a few more intelligent farmers or artisans each year, would be a wretchedly inadequate return for these endowments. The places for imparting the simple, usual practical education for agricultural and mechanical pursuits are the millions of farms and workshops in the country. Nowhere else can such practical knowledge be afforded so cheaply or so effectively.

The national institutions for education should, indeed, have farms and workshops; but the foremost object of these should be, not to afford simple employment to young men, but to give them, in connection with their studies in the sciences, what may be called *laboratories*, where they can see science applied in as practical a manner as possible—laboratories, whether field or shop, where they can see sciences limited by the necessities of practice. It cannot be too much insisted upon that the main object of these institutions should be to send out men, with minds trained by observation and experiment, to develop the various agricultural and other industries, and to improve them, and not simply to increase, by an almost infinitesimal fraction, the number of those engaged in the usual industries pursued with a little more intelligence, in the usual way.

But it is said that scientific and industrial education does not better agriculture. Does it not? Of all assertions this is the most fearful indictment against the most extended field of human thought and work. If this be true, then is agriculture the only industrial pursuit unworthy of a human being; for this assertion would not be made against any other branch of human industry. But it is not true. The whole history of agriculture shows exactly the reverse of this. Look at those wonderful "Tables in Comparative Sociology," by Herbert Spencer, just issued, and study there the progress of agriculture and other industries from their rudest beginnings, and you see that skill in observation and reasoning on observation have been steadily improving agriculture, at the same time that they have improved other industries.

But grant that the number of students devoted wholly to agriculture is small, it is not these alone whose education tells upon agriculture. Even a partial course in it has great value. It was the remark of a very distinguished statesman of this Commonwealth—one who occupied this desk as Speaker, yonder chamber as Governor, and who received the suffrages of many of his countrymen for the highest office in their gift—that the main thing in agricultural education is to do something to make agricultural pursuits attractive. His view is that whereas in England every man longs to obtain a competency to enable him to retire from the city, here men seek to escape from the country to the city; and that we should attempt to bring about a change of this sentiment in our educated young men. The author of that remark is Horatio Seymour. It struck me powerfully as sound and just, and, shortly after the establishment of the Cornell University, the trustees adopted a rule by which every student in every department—as a condition for graduation—must hear a course of lectures on general agriculture.

I am glad to state that, although the rule was received with some grumbling at first, that grumbling stopped immediately after the first lecture. Said a student to me at that time, "These lectures make us all wish to get hoes, and go at scratching up the ground at once." The lecturer for this general purpose is John Stanton Gould. May his interruption by ill health, which has deprived us of his service the past year, be but temporary! Long may he be spared to the University and the State, for whose good he has so steadily and so earnestly labored!

But suppose that no young men came forward to take agricultural studies, the new education would still tell powerfully on agriculture. Think you that we can send out year after year—as we did last year—a hundred graduates from all our various departments, whose powers of observation have been trained and whose real knowledge of subjects bearing on agriculture has been extended by close study in Botany, Animal Physiology, Geology, and Chemistry, without its telling ultimately on the progress of agriculture?

But suppose that not one student was even thus educated, I maintain that the State and nation would receive more than the equivalent of its endowment.

Look at a few figures. The last census gives certain agricultural statistics whose magnitude is almost oppressive. The value of farm productions in the United States, in the year 1870, was considerably over $2,000,000,000.

The value of farm productions in the State of New York, the same year, was over $250,000,000.

Does not common-sense tell us that we can well afford to make a little outlay to promote any sciences which may help such a vast interest? If in the course of years, in all these laboratories and experiments, some one useful idea shall be struck out, it would repay our endowments a thousand-fold.

Says Emerson, "The true poet is an inspired prophet." Did you ever think what an inspiration lies in the poet's declaration that "the greatest benefactor of mankind is he who makes two blades of grass grow where one grew before?" If not, look at the census returns showing the enormous value of the hay-crop of these Northern States.

Knowledge of Nature—coming by research and observation in the laboratory and the field—these are to give us finally our "two blades of grass," and multitudes of other benefactions to our race not less precious.

The Sheffield Scientific School at Yale College has not a single student in agriculture, but Profs. Brewer and Johnson, by their experiments on fertilizers and kindred subjects, have returned the value of their endowment to the nation a hundred-fold already.

Take another item. The dairy products of New York in 1870 were over 100,000,000 pounds of butter, and over 20,000,000 pounds of cheese. Now, there has been quietly at work, in our Laboratory of Agricultural Chemistry at Cornell University, a young professor, Mr. George C. Caldwell. He has made little noise in the world. While Dr. McCosh was striking the stars with his lofty head, and his voice was shaking the Agricultural Colleges, this young man worked quietly on upon the chemistry of the dairy. Said Mr. L. B. Arnold, an authority you all recognize, "Prof. Caldwell's researches on the chemistry of the dairy are worth more to the State than your whole endowment. He has taught us to do such things in dairy matters and to increase dairy products as we never dreamed of doing." And to this, substantially, Mr. Arnold has lately sworn before the Commission of Investigation.

Take a few figures more from the same census. In 1870 the market-garden and orchard products of the State of New York amounted in value to close upon $12,000,000.

Can any one, then, gainsay the wisdom of our employing, as we do, a young naturalist of genius to devote his whole time to investigations regarding insects injurious to vegetation, and to giving lectures based upon these researches?

Take still other figures. The same census shows the value of farm implements in the State of New York to be over $45,000,000. In view of this we have investigations and lectures upon mechanics related to agriculture, and have obtained models and implements at home and abroad to illustrate this subject. Is not the mere pittance this requires well laid out?

I remember some years since seeing a paragraph going the rounds of the papers, stating that President White had sent from Europe to Cornell University an Oxford professor and a horse-doctor. The charge was true. The Oxford professor was Goldwin Smith; "the horse-doctor" was Prof. James Law, formerly of the Royal Veterinary College at London. Each one of these men, in his way, has been a blessing to the University and to the country. But look at a few more figures from the census. The number of horses in the State of New York is over 800,000; the number of neat-cattle exceeds 2,000,000. Prof. Law's lecture-room is one of the most attractive places I know, for animal physiology is a study worthy of any man, but, even if he never taught a student, in view of this vast interest is it not well worth while to provide such a man to investigate such a subject?

Take another branch. We have been fitting up an establishment for experiments in the best rotation of crops and in the feeding of cattle. A careful and resident professor has been called to carry on these, and I trust that Mr. E. W. Stewart may be called to superintend them.

Some time since, in view of this matter, I visited certain cattle-feeding establishments with a gentleman whose sound sense on such matters you all recognize, Hon. George Geddes. Said he: "This experiment, fairly tried, will be worth to the State of New York more than your whole endowment, no matter which way it turns out—no matter whether 'soiling' is found profitable or unprofitable; to try this matter fully, and fairly, and scientifically, will be worth more than your endowment."

The act of 1862 also provides with special care for instruction in "BRANCHES RELATING TO THE MECHANIC ARTS."

If you doubt the wisdom of this, look again at the last census. There you find the manufactures of the United States valued at $4,000,000,000, and over 2,000,000 persons engaged in them. Can education be made useful to this vast interest? Other nations think so, and are laying out vast sums in this direction. Some of our sister States are doing admirably in this respect. Illinois and Massachusetts have made excellent provision for mechanical science, and the recent message of Governor Bagby, of Michigan, shows that good work is to be done in that State. In an address delivered before this Society a few years since I described some of those foreign institutions. I trust, then, that you will pardon me for describing that which we have since created in this State.

Thanks to one of our trustees, a noble provision has been added for this purpose to that originally made by the nation.

The Hon. Hiram Sibley, of Rochester, has erected a building, equipped it with lecture-rooms, draughting-rooms, a workshop supplied with the best machinery, and has given an endowment to support a Professor of Mechanical Engineering and a superintendent of the machine-shop. Besides this, Mr. Cornell has erected a shop for wood-working, and has provided water-power for both establishments.

What is the system? Young men come wishing to make themselves first-class mechanical engineers or master-mechanics, or to perfect themselves in any branch of mechanical industry. Under careful instructors, they are carried through the various sciences bearing on their profession. They are taught mathematics in all their relations to mechanics. In one room they go on with the mathematical and mechanical drawing of machinery, in another with free-hand drawing; in the laboratory they are taken through various processes bearing upon their profession. A certain number of hours every day they must give to the workshop, and there, in well-worn apron and rolled-up sleeves, they go on under careful supervision from the use of the simplest machinery and the plainest work to the most complicated. The purpose is to send out every year a body of young men with not merely a very high grade of theoretical instruction, but with most thorough practical instruction—men who cannot merely calculate the size of parts of a machine, but who can draw it after they have calculated it, and make it after they have drawn it. These are the men whom our country sorely needs to complete the organization of its great army of industry. Indeed, I know of no more pressing material need in this country. Our land has more mechanical ingenuity in it than any other; but did you ever think of its wretched misdirection and waste for want of industrial education? If not, stroll through the national Patent-Office. Look at a few facts. In one of our most important cities are engines for supplying that city with water—erected at vast expense. The whole amount was wasted. There is ingenuity in that vast machine, there is skill in it; but, for want of education regarding certain principles involved, the whole thing is failure and waste.

Take another case. A few years since, with a small party of our fellow-citizens, I visited the West Indies in a national ship. She was a noble vessel, and her engines had cost, it is said, nearly $800,000. The engines showed ingenuity; but they were so deficient in proper elements of construction that our voyage was prolonged until we were all given up as lost and had the honor of having our obituaries in the leading newspapers! The first voyage of those engines was the last. They were sold for old iron; and the sum lost on them alone was sufficient to endow the finest institution for mechanical engineering in the world! I might multiply examples of this sort, but this is enough to show what need exists for more careful training in this direction, and I pass to a kindred department.

Another great department bearing on a multitude of industries, directly and indirectly, is Civil Engineering. Take one among the fields of its activity. We have in the United States about seventy thousand miles of railway, and every year thousands of miles are added. I do not at all exaggerate when I say that millions on millions of dollars are lost every year by the employment of half-educated engineers. Proofs of this meet you on every side. Lines in wrong positions, bad grades and curves, tunnels cut and bridges built which might be avoided. All of us know the story.

But this is not all. Hardly a community which has not some story to tell of great losses entailed by bad engineering in other directions. I have known the traffic of a great city street interrupted for a year, because no engineer could be found able to make the calculations for a "skew arch" bridge, a thing which any graduate of a well-equipped department of engineering can do. I have known a city subjected to enormous loss by the failure of its water-supply system, because the engineer employed made no calculation for the friction of water in the pipes. I know a whole district sickened by miasma, because a half-taught engineer was intrusted with its drainage. We must prepare men for better work; and, for every dollar thus laid out, we shall create or save thousands.

Take next, then, SANITARY ENGINEERING. Science has, within a few years, made wonderful strides in revealing the origin and propagation of disease. The summaries recently made by President Barnard, Prof. Dalton, and Prof. Chandler, give an admirable view of this conquest. Mr. Baldwin Latham, in his recent book on "Sanitary Engineering," gives careful tables, showing the enormous reduction of consumption, typhus, and typhoid, in several English towns by the application of science to sewerage and water-supply. Dr. Beale, in his work on "Disease-Germs," shows by statistics that a proper application of engineering to sewerage would save 100,000 lives yearly in Great Britain. More and more is this matter becoming important in this country. Hardly one in twenty of our towns has any well-adjusted system of sewerage or water-supply, and in our rural districts vast tracts are made wretched by miasma.

Nor is this probably the worst. Vicious systems of heating and ventilation are probably doing more to break down the physical constitution of our people than all other causes combined. We see it everywhere in sickly women, and puny children, and men but half alive. The study of human physiology and the system of preventing and removing disease-germs should be combined, and young men should have the opportunity to fit themselves for grappling with the problems presented to sanitary engineers.

Few among us dream of the monstrous waste now entailed upon this country by imperfect instruction in MINING ENGINEERING and metallurgy. Take first the losses by fraud. A few years since our people were asked to invest in a Nevada mine of great richness. Half-educated mining geologists had certified to its value. But certain capitalists sent a young man, carefully educated in a scientific school, to examine and report. The young man on arriving found that the mine looked well enough, but on applying more scientific tests he found that an old worthless mine had been taken; that rich sulphurets had been brought and carefully placed in it at a cost of probably $100,000. His report exploded the fraud, and nearly $1,000,000 was saved—more than five times the sum that this scientific school received from the Government of the United States. This same gentleman also exploded a great diamond-mine fraud of the same sort.

Take another case. Not long since a party of gentlemen determined to invest several hundred thousand dollars in working certain iron-mines in this State. Just before their arrangements were finally made, and much against the will of many of the proposed stock-holders, a young graduate of one of the scientific schools which received the national endowment was sent to make an examination. He found that the veins contained titanium, and that the entire investment, should it be made, would be lost. His fee was $250; he prevented a loss of over $400,000.

You see now why Pennsylvania and Missouri and California and

Massachusetts are aroused as to this matter also, but you will perhaps say that New York is but little interested here. Look again at the census, and you will see how wretchedly you are mistaken. The value of the mining products in New York in 1870 was more than half that of the entire gold product of California. Here, too, we must follow up the good work begun by our Chandlers and Raymonds.

Look next at CHEMISTRY APPLIED TO MANUFACTURES. More and more the chemical laboratory is becoming a great central point in industrial education. Run over but two or three points out of many. A chemical discovery in coloring-matter has given us a substitute for madder, and restored the great area given to cultivation of that material to the increase of material for human sustenance. An apparently trivial application of another chemical principle has enabled Onondaga to purify its product so that it now competes with the world in the purity of its salt for the dairy. Another application has enabled another part of the State to make quantities of steel formerly undreamed of. And all this is but the beginning of the applications of chemistry to increase the well-being of the State and nation.

We must also make provision for instruction in ARCHITECTURE. Wealth and public spirit—individual and municipal—are now erecting myriads of costly buildings in all parts of our country. The number of uneducated architects is very great—the number of thoroughly prepared architects is very small. Have you ever considered the waste attendant upon this? Every month you hear of some architectural failure that costs life and treasure. To-day it is a church-floor which gives way, and a multitude of children are taken from the ruins mangled and dead; to-morrow it is a whole city quarter swept away by fire, because some half-taught architects knew no other way of producing architectural effect than by piling up combustible ornaments on inaccessible roofs.

Nor is that all. Our people are laying out millions on millions in buildings which within thirty years—in the advance of taste and knowledge—will be eye-sores and must come down. A building erected by a true architect will grow more beautiful for hundreds of years. A building erected by a sham architect will be an incubus in a quarter of a century. People are beginning to see this, and we are endeavoring to prepare men thoroughly to know the best materials, to calculate their strength in construction, and to combine material and construction according to everlasting laws, and not according to some pretty present fashion; and this is the purpose of our School of Architecture.

Look now at instruction in DRAWING. The casual visitor to an institution like that established in this State will often say something like this: "I can understand the value of your libraries, collections in natural history, apparatus, models, shops, and lecture-rooms; but what is the use of your great draughting-rooms?"

If I answer that drawing is taught in one for civil engineers; in another for mechanical engineers; in another for architects; in another free-hand drawing for all these together, he will say: "Why teach free-hand drawing at all? That is rather artistic than industrial."

Is it? Look at a few recents facts. A few years since the State of Massachusetts passed a law requiring free-hand drawing to be provided for in the public-school system throughout the State. The city of Boston did the same. State and city combined to call, from the great English school for industrial art at South Kensington, Mr. Walter Smith, at a salary of $5,000, to direct the schools of that city and State.

Mr. Smith has worked on, and the result is that already this instruction has been admirably developed. Now, why has this been done? Has the State of Massachusetts, which we have always known as so thoughful in its legislation and education, really fallen into mere dilettanteism? Not at all. Look at a few more figures from the census.

In 1870 the product of Massachusetts in printed cottons was over $17,000,000, and her product of other goods into which the arts of design enter as a matter of first importance was doubtless even more. Massachusetts is thoughtful as ever. She sees that other States are overtaking her in manufactures so far as quantity and quality of material are concerned, but she determines to distance them by spreading throughout her borders knowledge of the principles of beauty in design and skill in them. And she never did a wiser thing. It will tell on a multitude of industries. Why do we import such vast quantities of English, German, and Danish glassware and pottery?—because they are better in material than ours? No; but because they have a beauty in design which leads the most illiterate to choose them. Why do we import such quantities of silks and carpets and chintzes and wall-papers from France? The Cheneys make silks as good in quality on this side of the ocean as the Compagnie Lyonnaise make on the other; the Bigelows make carpets just as good in material here as the D'Aubusson factory makes there; and yet, when our wives and daughters see these foreign fabrics, they immediately prefer them. Why? Simply because there generally are in the foreign product a skill, a beauty, a taste in design, that appeal to that sense of beauty which God has implanted in the rudest of our race.

Other nations in this warfare of industry see this. England is devoting millions to art education, in order to keep up her manufactures, and it has established in the Privy Council a science and art section to direct this expenditure wisely; Germany is doing even more; France has been doing it for generations, and it has given her the supremacy thus far in a multitude of branches of manufacture.

If you wish to see how these nations have done and are doing this, look at Mr. Stetson's admirable little book on "Technical Education."

You will there see that Prussia alone gives industrial education in various branches to over 11,000 men. If you wish to see how public-spirited individuals have done this, visit the draughting-rooms of the Cooper Institute, and Worcester Institute, and Lafayette College.

Already the value of this is known to our manufacturers. Mr. Stebbins tells us that one silver-ware establishment in the city of New York pays a graduate of one of these foreign schools, for making designs and patterns, as high a salary as our Empire State gives its Governor.

But it may be said, "The French are naturally artistic; our people are not." But, look at history; see how it disposes of these short and easy excuses for doing nothing. The French are descended, on one side, from the most unartistic nation of antiquity, and on the other from painted barbarians. As to the former, one of their greatest poets boasted that his fellow-Romans could tyrannize over the world, but had no capacity for art. As to the latter, Guizot, one of the greatest of statesmen and historians, shows that the barbarian ancestors of the French had the same fundamental ideas as American savages.

When our ancestors were savages, their ancestors were savages. It is only a few generations since, if they wished for good artistic work, they had to send to Italy for it. The French are "naturally artistic" because Liancourt, and other patriots like him, began, a hundred years ago, to create those great systems of education—scientific, industrial, and artistic—which have given the French almost the monopoly in supplying products of skill and beauty to the markets of the whole world.

To complete the system provided by the great congressional act of 1862, it was declared that instruction in Military Tactics shall also be included.

Not least among the evidences of statesmanship in that bill was this last clause. The idea it embodies has been too long neglected. Of all fatal things for a republic, the most fatal is to have its educated men in various professions so educated that, in any civil commotion, they must cower in corners, and relinquish the control of armed force to communists and demagogues. The national colleges have carried out this part of the act, sometimes by giving advanced military instruction, but generally by careful drilling of the whole body of students. The system has been found to give health and manly dignity to the student; to the nation it is to give a great body of well-trained men, ready to organize and control the best elements of society against any outbreak of anarchy or treason.

And now a few words regarding the general education which goes with these various branches of industrial and scientific education. The student must be not only trained as a specialist, he must also be educated as a man and a citizen. Hence the necessity of blending into the various special courses certain general studies calculated to give breadth and foresight and insight. Among these I name, first, instruction in HISTORY AND POLITICAL SCIENCE.

On this subject, the "new education" lays stress, and especially on the history of our own race and country. The subject has been sadly neglected; but more and more it is seen that, to train men to build up the future, we must show them with what successes and failures their predecessors have built up the past.

Thought, too, should be stirred on the more pressing problems in SOCIAL SCIENCE, and among them the best methods of dealing with pauperism, crime, insanity, sanitary management, and public instruction. Foundations for study on these might, at least, be laid, and right direction given to those whose tastes turn toward participation in public affairs.

No thoughtful man will deny that it is well to give even to students in industrial branches access to the best thoughts of the best thinkers —the study of the great languages and LITERATURE does this—and especially is it done by the study of this wonderful language and literature of our own.

Another most important means of discipline and culture is to be found in the study of THE NATURAL SCIENCES. On these much of industrial and general progress depends. They discipline the power of observation, and reasoning upon observation. They give, too, a culture to the sense of beauty in form, and fitness in adaptation.

But I am aware that objection is made to the study of Natural Science on the ground of a dangerous materialistic tendency.

But can this objection be well founded? Among the many striking passages in Herbert Spencer's "Treatise on Education" is one of special interest on this point. He asks, what would any author think were a person to come into his presence, praise his works, and dwell upon their beauty and perfection, when the author knew that this flatterer had never read a single page, or even a single line, of them? And what, then, must the Great Author of all things think of one who thus comes into his presence, extols his works in all moods and tenses, the Great Author knowing that this flatterer has never studied out a line in the great book of Nature—nay, that he has discouraged others from studying it? I come now to certain GUIDING IDEAS—necessary in carrying out any worthy system of scientific and industrial education.

1. Of these I name UNSECTARIANISM. Our own charter makes "men of all sects and parties, and of no sect or party, equally eligible to all offices and appointments." For this, some good men have thought it their duty to denounce us from pulpit and press as "godless;" but it has proved our salvation. It has enlisted benefactors of every creed. That it has taken strong hold upon the people is shown by the millions given the institutions on this basis, and by the steady support of these despite all calumnies. There is no other possible basis for the development of great institutions for scientific and indus-

trial education. To confine their choice of professors to any one denomination, or circle of denominations, is to dwarf them; to put them under control of any synod, conference, association, council, or convention, is to strangle them.

2. I name FREEDOM OF CHOICE BETWEEN VARIOUS COURSES OF STUDY. The old way in the more venerable colleges and universities was, to force all students through one single classical course—the same for all. This system the "new education" discards. General courses in literature, science, and arts, are presented, as well as special courses having reference to the great industries; and the student, with the advice of friends and instructors, takes that which best suits the bent of his mind. We believe that the results are already better than those of the old system. Certainly they could not be worse. The famous "Blue-Book of the Parliamentary Commission" on advanced education, in England, shows that under the old system there seventy per cent. of the students in their great schools and universities take no real hold upon classical studies. Few will claim that our system of classical instruction is better than that in England. If any of you think it more promising, look at President Barnard's cogent statistics on this point. We make no opposition to classical instruction. We agree that, for those who take earnest hold of it, it is one of the noblest means of discipline and culture; but it is no less evident that for those who do not take hold of it—who merely "drone" over it—it is one of the worst.

3. I name EQUALITY IN POSITION AND PRIVILEGE BETWEEN DIFFERENT COURSES OF STUDY. I have already shown how courses of study in science, and especially those bearing on industry, have been held, in various places, virtually inferior to courses of study in literature. Against this we stand pledged. We are determined to hold all courses and all students as equal; educating them together, graduating them together, welcoming them back as alumni together. But the "new education" does not merely endeavor to give a greater range of studies, it seeks also to improve METHODS. Let me mention two of these:

1. I name the BETTER USE OF THE LECTURE SYSTEM. Those who knew Louis Agassiz well will never be at a loss to recall conversations, instructive and entertaining; but I think that, among them all, none conveyed a better mixture of philosophy and fun than his delineation of the recitation of text-books by rote, as it has been so long practised in our American colleges. No system was ever better calculated to deaden enthusiasm and stiffen knowledge. More and more we are coming to see that, wherever possible, we must bring the living mind to bear on the student. Thus may we supplement text-books, and take from them their present woodenness and dreariness.

2. I name THE UNION OF STUDY OF THINGS WITH STUDY ABOUT THINGS. Under the old system it was book in the morning, book in

the afternoon, book in the evening—an unceasing round of studying what men have said *about* things. Under the better system of the various institutions for scientific and industrial education, the student passes frequently from study about things to study of the things themselves, in laboratory or workshop, in draughting-room or museum, or in the field. Every science must now have its laboratory practice, and thereby are given to lectures and recitations reality and interest. Thereby is gained ability to bring theory to bear upon practice.

But an objection of another sort is raised. It is said, "Why give instruction in classical branches at all?" I answer, for three reasons: 1. Because the act of Congress declares expressly that they shall not be excluded. 2. Because to those who wish them they are an excellent means of culture. 3. Because we wish to avoid that old mistake of separating industrial and scientific students from classical students. Heretofore students in science and technology have been banished to some little special college in some remote corner of a town or State, while classical students have had all the prestige arising from connection with large and thoroughly equipped institutions. We stand upon the principle of considering one student the equal of another—the student in science and industry the equal of the student in classics. We stand against any separation which shall serve to perpetuate that old subordination of men in the new education to men in the old.

But it is objected that the new system does not provide for mental discipline. Never was a charge more absurd. Discipline comes by studies that take hold of a man, and of which he takes hold. Is it not evident that the new system, which adapts studies to the tastes and aims of men, is more sure to take hold and be taken hold of than the old system, which grinds all alike through the same processes and studies?

But it is said, "Why concentrate your resources in one institution?" I answer, because that is the only way in which you can ever have the work done. To erect, equip and maintain laboratories, workshops, farms, collections, libraries, observatories—all this demands great sums.

To have such institutions, you must pay the price. While the rule, as already stated, regarding preliminary public instruction, is to distribute resources, the rule in regard to advanced education—scientific, general, or industrial—is to concentrate resources. Look at it. The last report of the Bureau of Education shows in the United States 397 institutions called colleges or universities, and you can count on the fingers of your hands all those worthy of either name.

Wisely, then, have the great States refused to yield to clamors for scattering or frittering away these funds. Wisely have individuals poured out their wealth to supplement them.

To the institution in our own State already over $1,500,000 have been given by individuals, and I trust that this is but a beginning.

Do you say that this endowment may be too large? Compare the endowment for the increase of intellectual wealth with any one of a thousand endowments for the increase of material wealth. Look at the hotels of your great cities. Some of them have cost more than the entire outlay in buildings for advanced instruction throughout whole States.

But it may be said, "Why not devote all your resources to agricultural experiments and instruction?" I answer—1. The law of the United States does not allow it. 2. Because in the interest of agriculture itself we should educate men to develop other industries. What is the great want of our Western States at this moment? Greater agricultural production? No. What they want is, the development of great and varied manufacturing industries, so near them that it shall no longer take two-thirds of a bushel of corn to carry the other third from producer to consumer.

And, finally, it is objected to the "new education" that it is godless. There is nothing new in this charge. It has been made against every great step in the progress of science or education. And yet it has certainly been found that although ideas of religion are changed from age to age, the change has tended constantly to make these religious ideas purer and nobler. The majority of the Fathers of the Church held the new idea of the rotundity of the earth incompatible with salvation. Martin Luther thought Copernicus a blasphemer for his new idea that the earth revolves about the sun, and not the sun about the earth. Dean Cockburn declared the new science of Geology a study invented by the devil, and unlawful for Christians. When John Reuchlin and his compeers urged the substitution of studies in the classics for studies in the mediæval scholastic philosophy, their books were burned, and they themselves narrowly escaped the same fate.

No, my friends; every study which tends to improve the industry of mankind makes a man nobler and better. Every study which gives man to know more of the history of his race, gives him to see more and more clearly the finger of Providence in history; every study which brings his mind into contact with the thoughts of inspired men as exhibited in our literatures, builds up his manliness and his godliness, and every study which brings him into close contact with Nature in any of its fields not less surely lifts him "through Nature up to Nature's God."

I have thus sketched very meagrely the growth thus far of the "new education." Its roots are firm, for they take fast hold upon the strongest material necessities of our land; its trunk is thrifty, for it is fed by the most vitalizing currents of thought which sweep through our time; nay, the very blasts of opposition to this growth have but strengthened it; the winter of discontent through which it has passed has but toughened it; and in agriculture and every branch of industry; in every science and art which ministers to either; in all the development of human thought which is to make men better and braver, it is to bear a rich fruitage for the State, for the nation, and for mankind.

ABOUT CRABS.

By Rev. SAMUEL LOCKWOOD, Ph. D.

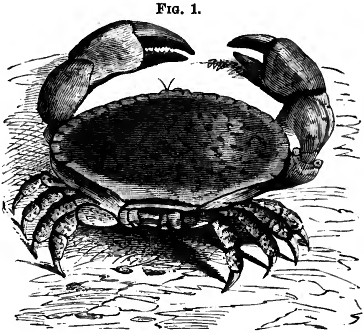
WITH one's eyes kept open, how very much there is to excite interest in a summer stroll beside the sea! Marine life—the creatures that represent the life-zone that belts or fringes the great murmuring world of waters—is so peculiar, some exquisitely beautiful, as the sea anemones, others droll and grotesque, as the great class known as the Crustacea. The tide is out. See that bird with bill curving upward. A beautiful functional adaptation it is—for with it small stones are turned over so deftly, and thus its food, the sheltered worms, are exposed. It is the avocet. So we turn avocet, using a stick in the operation. Ah! we have disturbed a poor polydactyled refugee in his retreat. See how threateningly he snaps at us his two pairs of pincers like formidable blacksmith-tongs. What a crusty-looking fellow he is! Now he is off, running sidewise; for they can go "forward, backward, and oblique." There is speed enough, but the gait is so comical. But crabs are given to flank-movements. We determine to try one on him; so with the stick just touching him laterally, and a fillip, and he is on his back. At this point, Frank, who is always facetious, and who had just been saying that he had come from the Bowling Green (he meant Alley), says, we have knocked the poor fellow off his pins—and that it was a ten-strike, adding for our enlightenment, "Don't you see that crab stands on ten pins?" Now, it so happens in this connection that it is just on this "ten-pin" arrangement that the naturalist founds his division *Decapoda*, as one of the three orders of the great class *Crustacea.* The decapods, or ten-footed, include the crabs and lobsters, and rank the highest in their class.

Those who cater to high-living are now announcing the arrival of "Soft-shell Crabs." We propose to give a succinct account of four of our commonest crabs, and shall in passing take note of these "soft shells."

An artist once made a picture of a child; a gay, graceful, romping, and petulant little one it was. It was years afterward, in another place, that he limned a youth, lovable and full of life. And it was long after this, and in some other place, that he painted the portrait of a full-grown man, with a countenance staid, stern, and uncompanionable. Although the artist did not then know it, the three paintings were of the same individual—it was simply the childhood, youth, and manhood, of one person. Many years ago the naturalist described a little crustacean which was noticed swimming gayly and briskly in the sea. It was a pert little thing, rather pretty, and very quaint. It had large, full eyes. In fact, they were enormously so for such a diminutive being. Between these great optics, projecting downward like the coulter of a plough, was a long, sharp spine. On each side of the body was a much shorter spine, and over this short spine on each side, and high up near the back, were two fan-like structures, almost suggestive of wings, as with these four it really sped its way through the water. Between these, and from its back, rose by far the longest spine, almost equal to its entire self in length. It was immensely long, yet delicate and sharp. This *outré* little thing received the name *Zoëa pelagica.* In rank it was considered an entomostracan, the lowest, the very *pariah* of the race. The naturalists also found another little crustacean, something larger, and not so testy-looking either. It had not the formidable spines, but it had feet on the abdomen, which Zoe had not. There were also other great differences. It had, however, like Zoe, large eyes; and so the systematists named it *Megalops.* Well, just here the joke comes in, if indeed we may suppose a joke possible in so serious a science as zoology, especially in the department of the crabs. But the fact was that Zoe, and Megalops, and Cancer, were but the childhood, youth, and adult stages of the same individual, namely, the crab. Now, as Cancer by common consent belongs rightly to the highest crustacean rank—that is, the decapods—so do Zoëa and Megalops.

The common edible crab of Europe has for its scientific name

Fig. 1.

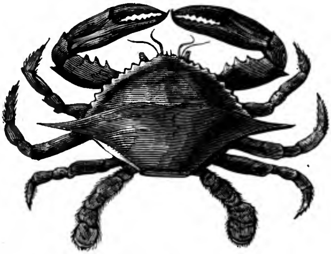


Common Crab of Europe.

Cancer pagurus. It is a much more massive crab than our edible crabs; individuals have been known to weigh twelve pounds each! Let the reader compare the cut of the European crab, Fig. 1, with that of the American edible crab (*Lupa dicantha*), Fig. 2. It will be noticed that our species has a sharp, spiny extension each side of the carapace, and a pair of oar-like, swimming legs behind. It is a much more active animal.

All crustaceans exuviate, or cast their hard, shelly covering at least once a year. It has been said quite graphically that "the new integument is so soft and yielding, and the muscles in such a flaccid condition, that the limbs are drawn through the small openings at the

Fig. 2.



American Edible Crab.

joints, much as a sack nearly filled with some fluid may be drawn through an opening much smaller than the sack itself." It should not be forgotten, however, that the neck in the great claws, or nippers, is crossed by thin, knife-like blades, or plates of shell; and it is certain that in drawing out the thumbs they are cut into long shreds, which doubtless, when drawn out, come together immediately and heal.

As giving a peep at the private life of the European crabs, let us skim off the cream of a paragraph from Gosse. The naturalist has been exploring the rocks on the English coast, and says:

"Peering into a hole I saw a fine large crab. I pulled him out, and carried him home. There came out with him the claw of a crab of similar size, but quite soft, which I supposed might have been carried in there by my gentleman to eat. After I had got him out—it was a male—I looked in, and saw another at the bottom of the hole. Arrived at home, I found that I had left my pocket-knife at the mouth of the crab-hole. I returned; the crab had not moved. I drew it out. But lo! it was a soft crab, the shell being of the consistence of wet parchment. It was a female, too, and had lost one claw. What, then, are we to infer from this association? Do the common crabs live in pairs? And does one keep guard at the mouth of the cavern, while its consort is undergoing its change of skin? I have no doubt that the claw of its mate was unintentionally torn off in its efforts to effect some hold, when resisting my tugs in dragging him out."

But it is in America, after all, that the habits of crabs at their time of exuviation should be the best known. The soft-shell crab is condemned as food in Europe, it being considered as in a sickly state at that time, just as birds are when moulting. And may not this be so? However, in this country the procuring of the soft-shell crab is a great and profitable industry. Hence any intelligent "crabber" knows a good deal of their habits. For many years we knew an old fisherman. He was quite illiterate, but of more than the average intelligence of his class. He was an old "crabber" too. As he long supplied my family with fish, I often got him into conversation. But here I must be allowed to quote myself, as in the *American Naturalist*, vol. iii., giving the old man's own words: "I hev ketched soft crabs for market many a year. The crab sheds every year, chiefly in early summer. At that time the he one is mighty kind to his mate. When she shows signs of shedding, the he one comes along, and gets on the she one's back, quite tenderly-like, and entirely protects her from all enemies, whether of fishes, or of their own kind. She is now getting ready to shed, and is called a *shedder*. Soon the back begins to burst nigh to the tail. She is then called a *buster*. The he one is then very anxious to find a good place for her, either by digging a hole in the sand, or mud, or else looking up a good cover under some sea-weed. Here he brings her, all the time hovering nigh, and doing battle for her, if any thing comes along. She now—and it only takes a few minutes—withdraws from the old shell. And she comes out perfect, in every part, even to the inside of the hairs, the eyes, and long feelers, almost like the whiskers of a cat. At the first tide she is *fat*, and the shell is soft, just like a thin skin. She is then called a *soft-shell*, and it's the first-tiders that bring the high price. At the second tide she is perfectly watery, and transparent, and is then called a *buckler*; but she is not worth much then. At the third tide she is again a *hard-shell*, as she always was, only bigger."

"Have you seen all this with your own eyes?" we asked.

"Lor', sir, yes; hundreds and hundreds of times."

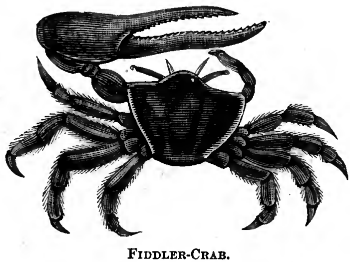
To the epicure, the soft-shell crab, when fried, is a great dainty. It is eaten entirely, like boned turkey; and, as a luxury, might be compared to a boneless fish. That it is an entirely unobjectionable food, is far from certain. It does not agree with every one, that is sure. It is a great business in New Jersey. Almost any morning, in summer, the sight may be seen at the Port Monmouth dock of unloading them from the cars on to the steamboat. They are shipped to market in boxes, each containing about six dozen of these soft-shell crabs, and covered on the top with wet sea-weed. Some idea of the importance of this business, while it lasts, may be formed from the fact that the neighborhood of Shark River will ship daily about five hundred dozen. These will bring, on an average, about $1.50 a dozen. When scarce, they bring almost fabulous prices. The business is, however, somewhat precarious. In some places, noted for being good, a seeming desertion sometimes occurs, which may continue for several seasons. Shark River is a good crabbing-ground, and yet it is subject to a closing up at the mouth by the washing up of the sea. When this occurs, the water is too fresh, and the crabs may perish.

The crabbers are now working more systematically. They build pens, or cars, out in the water, the top being opened to the light, and the sides being latticed, or made of laths, which admit the water freely. The bottom is covered with clean stones or coarse gravel. Into these the crabs are put as fast as caught, whether shedding or not; and, as fast as they shed, they are taken out.

As mentioned, our edible crab literally backs out of the shell; that is, it comes out at an opening behind. The *Limulus*, or horseshoe-crab, acts directly contrariwise. The shell cracks open at the front, and the animal emerges forward, instead of from behind, or backward. In fact, the structure of the shell makes this the only possible mode. A few years ago, the officers superintending the building of the fort at Sandy Hook became greatly interested at witnessing this exuviation of the shell of *Limulus Polyphemus*, and they declared that the fellow was spewing himself out of his mouth!

But we have two others to introduce—a brace of queer creatures they are, truly; and one of them is a positively "crusty customer." Some call him the soldier-crab; and certainly, if agility and seeming courage make up the martial element, then a valorous little fellow he is. The males have one hand enormously large. This, when closed upon the front of the body, is suggestive of the attitude of a violinist—hence we boys used to call it the fiddler-crab, Fig. 3. The natural-

Fig. 3.

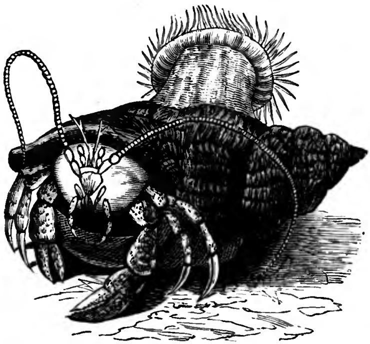


Fiddler-Crab.

ist names it *Gelasimus vocans*, a name highly expressive of its attributes. Some have rendered the words "calling crab." This is too far short of their significance. The words are intended to indicate both the action of the crab and its effect upon the beholder. When alarmed, they go scuttling over the mud to their burrows, the males each holding his great claw aloft, and waving it in a manner that looks ludicrously like beckoning, or challenging, and at the same time threatening, and this, too, while in full and masterly retreat. Each seems, as it might be, a Liliputian Falstaff; and, if rendered in Homeric strain, *Gelasimus vocans* would signify the "laughter-provoking challenger." Indeed, Gelasimus never sees anybody, whether great or small, but forth he hurls his challenge in pantomime, for up goes that threatening huge member, so that its owner appears to be habitually bent on something high-handed. As this swaying of the great fiddle-like claw seems to start and direct or animate the retreat, it is ludicrously suggestive of a musical conductor beating time by swaying a bass-viol instead of his *bâton*, the effect of his eccentricity being to cause a stampede of all the fiddlers. This crab excavates holes in the earth, a male and a female occupying one hole. Into this retreat it retires with astonishing celerity when alarmed, and, having gained its hole, it literally barricades the entrance, by turning round and closing it up with its big hand, leaving just room enough for the little keen eyes to keep a sharp lookout at whatever may be passing. In these burrows they spend the winter, probably in hibernation. More than once, when pursuing the fiddler who, with fiddle aloft, ran swiftly, has the writer had the luxury of a slip and fall on the slimy clay of Fiddler Town, as we called a certain place in the salt-meadows, where these fiddlers lived. Those mishaps were really enjoyable—that is, to those who looked on.

There is a group of crabs which has a curious habit, made necessary on account of the unprotected condition of the hinder part of

Fig. 4.



Hermit-Crab and Actinea.

their bodies. This is entirely naked; hence these crabs occupy the empty shells of sea-snails, winkles, and such univalves. It is called the hermit-crab, or *Pagurus*, by the systematists, Fig. 4. The most common species on the Atlantic coast is the little hermit—*Pagurus longicarpus*. A pair of nippers at the extremity of the tail, or naked abdomen, enables it to grip the columella, or upper part of the inside of the shell that it occupies, thus keeping itself snugly in place. As the crab increases in size by growth, it has to change its home for one more roomy; and this leads to some remarkable exhibitions of its instincts. The sight, which we have often beheld, is one of exciting interest. Watch, now, if you please. Here is a fat little hermit-crab, whose domicile, like a strait-jacket, has become decidedly uncomfortable, and he is somewhat distracted about it. He is out a house-hunting—that is a literal fact. See, he has found an empty shell. It is not so handsome as the one he now occupies, but it is a little larger. Look, how he almost lifts it up among his ten feet, every one of which is an interested inspector, as each must bear its part in sustaining the establishment. Now he rolls it round and round, all over and over, delicately manipulating its sculpture occasionally; he is not only testing its specific gravity like a philosopher, but also seems to have an eye to appearances. Now comes the most essential, the inspection of the interior. Will it fit? That is the chief consideration. He inserts his longest finger, and thoroughly probes the whole matter. One more trial—and now it seems that the antennæ, or feelers, enter into the consultation. And what an amount of feeling deliberation does this step involve! Well, the thing appears to be satisfactory. It is evidently decided that the new house will answer. And now comes the most trying time of all—for "moving" is a trying time. But Pagurus is actuated by considerations that fall not to the lot of migratory mortals of the bipedal sort. His accountability is of the ten-talent order. With his eyes he surveys the entire situation. What! Yes, it is so! He has moved, and settled, and has got the house "all to-rights." The whole thing was done in the twinkling of an eye. It vacates the old house, whisks its tail round, and enters the new one backward, as if shot into it from a gun. In fact, unless watching intently, the whole movement will elude the eye, like a trick of legerdemain. And the cause is not far to seek. If that soft, nude, defenceless body were exposed but for an instant, it might become the prey of some darting fish.

These hermit-crabs are highly pugnacious. We once took a pair of them that we suspected of being anxious to change their houses. They were put in a vessel of sea-water, and, full in sight of them, was placed an empty winkle-shell, which we supposed was of the right size. How they did fight for it! It was a battle for life. One succumbed, at last, and died. The survivor coolly surveyed his victim, and then surveyed the new premises. After this, he promptly entered into possession; and then, pitiful to relate, he fell-to eating his defunct comrade. Oh, the cannibal!

The cut (Fig. 4) given of a hermit-crab shows actinea, or zoöphite, upon the shell. These are sometimes called sea-anemones, and animal flowers, on account of their being real animals, with a flower-like form.

The class Crustacea, which embraces the creatures of whom we have given this brief sketch, is immense in the number of species which compose it; and these have a wide range of size, some being so small as to be only discernible by the microscope, while some are many feet in length. The hugest of them all is a spider-like creature, the *Macrocheira*, or long-armed crab of Japan. The cabinet of Rutgers College, New Jersey, contains one of them. It is the *Macrocheira Camperi*. We made an actual measure of it, and found that, with its long limbs extended, it had a length of eleven feet six inches. This specimen is probably the largest known.

After a while, a crab ceases to grow. Of course, then all enlargement stops, and it is no longer necessary for it to get new clothes, as the old ones are large enough. It is liable now to become the victim of the strangest sort of parasitism. In the British Museum is an old crab of the edible species, with some half-dozen oysters of large size growing on its back, which load, ever increasing, the old crab was doomed to carry to the end of its days. A singular piece of imposition—and enough to make crabbed the disposition of the most amiable. Another specimen preserved is that of a hairy crab, whose habit seems to have been to encourage the presence of sponges. And it got "sponged on" with a vengeance, seeing that it is not larger than a walnut, and yet is saddled with a sponge as big as a man's fist.

SEX IN MIND AND IN EDUCATION.

By HENRY MAUDSLEY, M. D.

THOSE who view without prejudice, or with some sympathy, the movements for improving the higher education of women, and for throwing open to them fields of activity from which they are now excluded, have a hard matter of it sometimes to prevent a feeling of reaction being aroused in their minds by the arguments of the most eager of those who advocate the reform. Carried away by their zeal into an enthusiasm which borders on or reaches fanaticism, they seem positively to ignore the fact that there are significant differences between the sexes, arguing in effect as if it were nothing more than an affair of clothes, and to be resolved, in their indignation at woman's wrongs, to refuse her the simple rights of her sex. They would do better in the end if they would begin by realizing the fact that the male organization is one, and the female organization another, and that, let come what may in the way of assimilation of female and male education and labor, it will not be possible to transform a woman into a man. To the end of the chapter she will retain her special functions, and must have a special sphere of development and activity determined by the performance of those functions.

It is quite evident that many of those who are foremost in their zeal for raising the education and social status of woman, have not given proper consideration to the nature of her organization, and to the demands which its special functions make upon its strength. These are matters which it is not easy to discuss out of a medical journal; but, in view of the importance of the subject at the present stage of the question of female education, it becomes a duty to use plainer language than would otherwise be fitting in a literary journal. The gravity of the subject can hardly be exaggerated. Before sanctioning the proposal to subject woman to a system of mental training which has been framed and adapted for men, and under which they have become what they are, it is needful to consider whether this can be done without serious injury to her health and strength. It is not enough to point to exceptional instances of women who have undergone such a training, and have proved their capacities when tried by the same standard as men; without doubt there are women who can, and will, so distinguish themselves, if stimulus be applied and opportunity given; the question is, whether they may not do it at a cost which is too large a demand upon the resources of their nature. Is it well for them to contend on equal terms with men for the goal of man's ambition?

Let it be considered that the period of the real educational strain will commence about the time when, by the development of the sexual system, a great revolution takes place in the body and mind, and an extraordinary expenditure of vital energy is made, and will continue through those years after puberty when, by the establishment of periodical functions, a regularly recurring demand is made upon the resources of a constitution that is going through the final stages of its growth and development. The energy of a human body being a definite and not inexhaustible quantity, can it bear, without injury, an excessive mental drain as well as the natural physical drain which is so great at that time? Or, will the profit of the one be to the detriment of the other? It is a familiar experience that a day of hard physical work renders a man incapable of hard mental work, his available energy having been exhausted. Nor does it matter greatly by what channel the energy be expended; if it be used in one way it is not available for use in another. When Nature spends in one direction, she must economize in another direction. That the development of puberty does draw heavily upon the vital resources of the female constitution, needs not to be pointed out to those who know the nature of the important physiological changes which then take place. In persons of delicate constitution who have inherited a tendency to disease, and who have little vitality to spare, the disease is apt to break out at that time; the new drain established having deprived the constitution of the vital energy necessary to withstand the enemy that was lurking in it. The time of puberty and the years following it are therefore justly acknowledged to be a critical time for the female organization. The real meaning of the physiological changes which constitute puberty is, that the woman is thereby fitted to conceive and bear children, and undergoes the bodily and mental changes that are connected with the development of the reproductive system. At each recurring period there are all the preparations for conception, and nothing is more necessary to the preservation of female health than that these changes should take place regularly and completely. It is true that many of them are destined to be fruitless so far as their essential purpose is concerned, but it would be a great mistake to suppose that on that account they might be omitted or accomplished incompletely, without harm to the general health. They are the expressions of the full physiological activity of the organism. Hence it is that the outbreak of disease is so often heralded, or accompanied, or followed by suppression or irregularity of these functions. In all cases they make a great demand upon the physiological energy of the body: they are sensitive to its sufferings, however these be caused; and, when disordered, they aggravate the mischief that is going on.

When we thus look the matter honestly in the face, it would seem plain that women are marked out by Nature for very different offices in life from those of men, and that the healthy performance of her special functions renders it improbable she will succeed, and unwise for her to persevere, in running over the same course at the same pace with him. For such a race she is certainly weighted unfairly. Nor is it a sufficient reply to this argument to allege, as is sometimes done, that there are many women who have not the opportunity of getting married, or who do not aspire to bear children; for whether they care to be mothers or not, they cannot dispense with those physiological functions of their nature that have reference to that aim, however much they might wish it, and they cannot disregard them in the labor of life without injury to their health. They cannot choose but to be women: cannot rebel successfully against the tyranny of their organization, the complete development and function whereof must take place after its kind. This is not the expression of prejudice nor of false sentiment; it is the plain statement of a physiological fact. Surely, then, it is unwise to pass it by; first or last it must have its due weight in the determination of the problem of woman's education and mission; it is best to recognize it plainly, however we may conclude finally to deal with it.

It is sometimes said, however, that sexual difference ought not to have any place in the culture of the mind, and one hears it affirmed with an air of triumphant satisfaction that there is no sex in mental culture. This is a rash statement, which argues want of thought or insincerity of thought in those who make it. There is sex in mind as distinctly as there is sex in body; and, if the mind is to receive the best culture of which its nature is capable, regard must be had to the mental qualities which correlate differences of sex. To aim, by means of education and pursuits in life, to assimilate the female to the male mind, might well be pronounced as unwise and fruitless a labor as it would be to strive to assimilate the female to the male body by means of the same kind of physical training and by the adoption of the same pursuits. Without doubt there have been some striking instances of extraordinary women who have shown great mental power, and these may fairly be quoted as evidence in support of the right of women to the best mental culture; but it is another matter when they are adduced in support of the assertion that there is no sex in mind, and that a system of female education should be laid down on the same lines, follow the same method, and have the same ends in view, as a system of education for men.

Let me pause here to reflect briefly upon the influence of sex upon mind. In its physiological sense, with which we are concerned here, mind is the sum of those functions of the brain which are commonly known as thought, feeling, and will. Now, the brain is one among a number of organs in the commonwealth of the body; with these organs it is in the closest physiological sympathy by definite paths of nervous communication, has special correspondence with them by internuncial nerve-fibres; so that its functions habitually feel and declare the influence of the different organs. There is an intimate consensus of functions. Though it is the highest organ of the body, the coördinating centre to which impressions go and from which responses are sent, the nature and functions of the inferior organs with which it lives in unity affect essentially its nature as the organ of mental functions. It is not merely that disorder of a particular organ hinders or oppresses these functions, but it affects them in a particular way; and we have good reason to believe that this special pathological effect is a consequence of the specific physiological effect which each organ exerts naturally upon the constitution and function of mind. A disordered liver gives rise to gloomy feelings; a diseased heart, to feelings of fear and apprehension; morbid irritation of the reproductive organs, to feelings of a still more special kind—these are familiar facts; but what we have to realize is, that each particular organ has, when not disordered, its specific and essential influence in the production of certain passions or feelings. From of old the influence has been recognized, as we see in the doctrine by which the different passions were located in particular organs of the body, the heart, for example, being made the seat of courage, the liver the seat of jealousy, the bowels the seat of compassion; and although we do not now hold that a passion is aroused anywhere else than in the brain, we believe nevertheless that the organs are represented in the primitive passions, and that, when the passion is aroused into violent action by some outward cause, it will discharge itself upon the organ and throw its functions into commotion. In fact, as the uniformity of thought among men is due to the uniform operation of the external senses, as they think alike because they have the same number and kind of senses, so the uniformity of their fundamental passions is due probably to the uniform operation of the internal organs of the body upon the brain; they feel alike because they have the same number and kind of internal organs. If this be so, these organs come to be essential constituents of our mental life.

The most striking illustration of the kind of organic action which I am endeavoring to indicate, is yielded by the influence of the reproductive organs upon the mind; a complete mental revolution being made when they come into activity. As great a change takes place in the feelings and ideas, the desires and will, as it is possible to imagine, and takes place in virtue of the development of their functions. Let it be noted, then, that this great and important mental change is different in the two sexes, and reflects the difference of their respective organs and functions. Before experience has opened their eyes, the dreams of a young man and maiden differ. If we give attention to the physiology of the matter, we see that it cannot be otherwise, and if we look to the facts of pathology, which would not fitly be in place here, they are found to furnish the fullest confirmation of what might have been predicted. To attribute to the influence of education the mental differences of sex which declare themselves so distinctly at puberty, would be hardly less absurd than to attribute to education the bodily differences which then declare themselves. The comb of a cock, the antlers of a stag, the mane of a lion, the beard of a man, are growths in relation to the reproductive organs which correlate mental differences of sex as marked almost as these physical differences. In the first years of life, girls and boys are much alike in mental and bodily character, the differences which are developed afterward being hardly more than intimated, although some have thought the girl's passion for her doll evinces even at that time a forefeeling of her future functions; during the period of reproductive activity, the mental and bodily differences are declared most distinctly; and when that period is past, and man and woman decline into second childhood, they come to resemble one another more again. Furthermore, the bodily form, the voice, and the mental qualities of mutilated men approach those of women; while women whose reproductive organs remain from some cause in a state of arrested development, approach the mental and bodily habits of men.

No psychologist has yet devoted himself to make, or has succeeded in making, a complete analysis of the emotions, by resolving the complex feelings into their simple elements and tracing them back from their complex evolutions to the primitive passions in which they are rooted; this is a promising and much-needed work which remains to be done; but, when it is done, it will be shown probably that they have proceeded originally from two fundamental instincts, or—if we add consciousness of nature and aim—passions, namely, that of self-preservation, with the ways and means of self-defense which it inspires and stimulates, and that of propagation, with the love of offspring and other primitive feelings that are connected with it. Could we in imagination trace mankind backward along the path stretching through the ages, on which it has gone forward to its present height and complexity of emotion, and suppose each new emotional element to be given off at the spot where it was acquired, we should view a road along which the fragments of our high, special, and complex feelings were scattered, and should reach a starting-point of the primitive instincts of self-preservation and propagation. Considering, then, the different functions of the sexes in the operation of the latter instinct, and how a different emotional nature has necessarily been grafted on the original differences in the course of ages,[1] does it not appear that in order to assimilate the female to the male mind it would be necessary to undo the life-history of mankind from its earliest commencement? Nay, would it not be necessary to go still farther back to that earliest period of animal life upon earth before there was any distinction of sex?

If the foregoing reflections be well grounded, it is plain we ought to recognize sex in education, and to provide that the method and aim of mental culture should have regard to the specialties of woman's physical and mental nature. Each sex must develop after its kind; and if education in its fundamental meaning be the external cause to which evolution is the internal answer, if it be the drawing out of the internal qualities of the individual into their highest perfection by the influence of the most fitting external conditions, there must be a difference in the method of education of the two sexes answering to differences in their physical and mental natures. Whether it be only the statement of a partial truth, that "for valor he" is formed, and "for beauty she and sweet attractive grace," or not, it cannot be denied that they are formed for different functions, and that the influence of these functions pervades and affects essentially their entire beings. There is sex in mind, and there should be sex in education.

Let us consider, then, what an adapted education must have regard to. In the first place, a proper regard to the physical nature of women means attention given, in their training, to their peculiar functions and to their foreordained work as mothers and nurses of children. Whatever aspirations of an intellectual kind they may have, they cannot be relieved from the performance of those offices so long as it is thought necessary that mankind should continue on earth. Even if these be looked upon as somewhat mean and unworthy offices in comparison with the nobler functions of giving birth to and developing ideas; if, agreeing with Goethe, we are disposed to hold—"Es wäre doch immer

[1] The instinct of propagation is what we are concerned with here, but it should not be overlooked that, in like manner, a difference of character would grow out of the instinct of self-preservation and the means of self-defense prompted by it.

hübscher wenn man die Kinder von den Baumen schüttelte;" it must still be confessed that for the great majority of women they must remain the most important offices of the best period of their lives. Moreover, they are work which, like all work, may be well or ill done, and which, in order to be done well, cannot be done in a perfunctory manner, as a thing by the way. It will have to be considered whether women can scorn delights, and live laborious days of intellectual exercise and production, without injury to their functions as the conceivers, mothers, and nurses of children. For, it would be an ill thing, if it should so happen that we got the advantages of a quantity of female intellectual work at the price of a puny, enfeebled, and sickly race. In this relation, it must be allowed that women do not and cannot stand on the same level as men.

In the second place, a proper regard to the mental nature of woman means attention given to those qualities of mind which correlate the physical differences of her sex. Men are manifestly not so fitted mentally as women to be the educators of children during the early years of their infancy and childhood; they would be almost as much out of place in going systematically to work to nurse babies as they would be in attempting to suckle them. On the other hand, women are manifestly endowed with qualities of mind which specially fit them to stimulate and foster the first growths of intelligence in chilren, while the intimate and special sympathies which a mother has with her child as a being which, though individually separate, is still almost a part of her nature, give her an influence and responsibilities which are specially her own. The earliest dawn of an infant's intelligence is its recognition of its mother as the supplier of its wants, as the person whose near presence is associated with the relief of sensations of discomfort, and with the production of feelings of comfort; while the relief and pleasure which she herself feels in yielding it warmth and nourishment strengthen, if they were not originally the foundation of, that strong love of offspring which with unwearied patience surrounds its wayward youth with a thousand ministering attentions. It can hardly be doubted that, if the nursing of babies were given over to men for a generation or two, they would abandon the task in despair or in disgust, and conclude it to be not worth while that mankind should continue on earth. But "can a woman forget her sucking child, that she should not have compassion on the son of her womb?" Those can hardly be in earnest who question that woman's sex is represented in mind, and that the mental qualities which spring from it qualify her especially to be the successful nurse and educator of infants and young children.

Furthermore, the female qualities of mind which correlate her sexual character adapt her, as her sex does, to be the helpmate and companion of man. It was an Eastern idea, which Plato has expressed allegorically, that a complete being had in primeval times been divided into two halves, which have ever since been seeking to unite together and to reconstitute the divided unity. It will hardly be denied that there is a great measure of truth in the fable. Man and woman do complement one another's being. This is no less true of mind than it is of body; is true of mind indeed as a consequence of its being true of body. Some may be disposed to argue that the qualities of mind which characterize women now, and have characterized them hitherto, in their relations with men, are in great measure, mainly if not entirely, the artificial results of the position of subjection and dependence which she has always occupied; but those who take this view do not appear to have considered the matter as deeply as they should; they have attributed to circumstances much of what unquestionably lies deeper than circumstances, being inherent in the fundamental character of sex. It would be a delusive hope to expect, and a mistaken labor to attempt, to eradicate by change of circumstances the qualities which distinguish the female character, and fit woman to be the helpmate and companion of man in mental and bodily union.

So much may be fairly said on general physiological grounds. We may now go on to inquire whether any ill effects have been observed from subjecting women to the same kind of training as men. The facts of experience in this country are not such as warrant a full and definite answer to the inquiry, the movement for revolutionizing the education of women being of a recent date. But in America the same method of training for the sexes in mixed classes has been largely applied; girls have gone with boys through the same curriculum of study, from primary to grammar schools, from schools to graduation in colleges, working early under the stimulus of competition, and disdaining any privilege of sex. With what results? With one result certainly—that, while those who are advocates of the mixed system bear favorable witness to the results upon both sexes, American physicians are beginning to raise their voices in earnest warnings and protests. It is not that girls have not ambition, nor that they fail generally to run the intellectual race which is set before them, but it is asserted that they do it at a cost to their strength and health which entails life-long suffering, and even incapacitates them for the adequate performance of the natural functions of their sex. Without pretending to indorse these assertions, which it would be wrong to do in the absence of sufficient experience, it is right to call attention to them, and to claim serious consideration for them; they proceed from physicians of high professional standing, who speak from their own experience, and they agree, moreover, with what perhaps might have been feared or predicted on physiological grounds. It may fairly be presumed that the stimulus of competition will act more powerfully on girls than on boys; not only because they are more susceptible by nature, but because it will produce more effect upon their constitutions when it is at all in excess. Their nerve-centres being in a state of greater instability, by reason of the development of their reproductive functions, they will be the more easily and the more seriously deranged. A great argument used in favor of a mixed education is that it affords adequate stimulants to girls for thorough and sustained work, which have hitherto been a want in girls' schools; that it makes them less desirous to fit themselves only for society, and content to remain longer and work harder at school. Thus it is desired that emulation should be used in order to stimulate them to compete with boys in mental exercises and aims, while it is not pretended they can or should compete with them in those out-door exercises and pursuits which are of such great benefit in ministering to bodily health, and to success in which boys, not unwisely perhaps, attach scarcely less honor than to intellectual success. It is plain, then, that the stimulus of competition in studies will act more powerfully upon them, not only because of their greater constitutional susceptibility, but because it is left free to act without the compensating balance of emulation in other fields of activity. Is it right, may well be asked, that it should be so applied? Can woman rise high in spiritual development of any kind unless she take a holy care of the temple of her body?[1]

A small volume, entitled "Sex in Education," which has been published recently by Dr. Edward Clarke, of Boston, formerly a professor in Harvard College, contains a somewhat startling description of the baneful effects upon female health which have been produced by an excessive educational strain. It is asserted that the number of female graduates of schools and colleges who have been permanently disabled to a greater or less degree by improper methods of study, and by a disregard of the reproductive apparatus and its functions, is so great as to excite the gravest alarm, and to demand the serious attention of the community. "If these causes should continue for the next half-century, and increase in the same ratio as they have for the last fifty years, it requires no prophet to foretell that the wives who are to be the mothers in our republic must be drawn from transatlantic homes. The sons of the New World will have to react, on a magnificent scale, the old story of unwived Rome and the Sabines." Dr. Clarke relates the clinical histories of several cases of tedious illness, in which he traced the cause unhesitatingly to a disregard of the function of the female organization. Irregularity, imperfection, arrest, or excess, occurs in consequence of the demand made upon the vital powers at times when there should rightly be an intermission or remission of labor, and is

[1] Of all the intellectual errors of which men have been guilty, perhaps none is more false and has been more mischievous in its consequences than the theologico-metaphysical doctrine which inculcated contempt of the body as the temple of Satan, the prison-house of the spirit, from which the highest aspiration of mind was to get free. It is a foolish and fruitless labor to attempt to divorce or put asunder mind and body, which Nature has joined together in essential unity; and the right culture of the body is not less a duty than, is indeed essential to, the right culture of the mind.

followed first by pallor, lassitude, debility, sleeplessness, headache, neuralgia, and then by worse ills. The course of events is something in this wise: The girl enters upon the hard work of school or college at the age of fifteen years or thereabouts, when the function of her sex has perhaps been fairly established; ambitious to stand high in class, she pursues her studies with diligence, perseverance, constancy, allowing herself no days of relaxation or rest out of the school-days, paying no attention to the periodical tides of her organization, unheeding a drain "that would make the stroke oar of the university crew falter." For a time all seems to go well with her studies; she triumphs over male and female competitors, gains the front rank, and is stimulated to continued exertions in order to hold it. But in the long-run Nature, which cannot be ignored or defied with impunity, asserts its power; excessive losses occur; health fails, she becomes the victim of aches and pains, is unable to go on with her work, and compelled to seek medical advice. Restored to health by rest from work, a holiday at the sea-side, and suitable treatment, she goes back to her studies, to begin again the same course of unheeding work, until she has completed the curriculum, and leaves college a good scholar but a delicate and ailing woman, whose future life is one of more or less suffering. For she does not easily regain the vital energy which was recklessly sacrificed in the acquirement of learning; the special functions which have relation to her future offices as woman, and the full and perfect accomplishment of which is essential to sexual completeness, have been deranged at a critical time; if she is subsequently married, she is unfit for the best discharge of maternal functions, and is apt to suffer from a variety of troublesome and serious disorders in connection with them. In some cases the brain and the nervous system testify to the exhaustive efforts of undue labor, nervous and even mental disorders declaring themselves.

Such is a picture, painted by an experienced physician, of the effects of subjecting young women to the method of education which has been framed for young men. Startling as it is, there is nothing in it which may not well be true to Nature. If it be an effect of excessive and ill-regulated study to produce derangement of the functions of the female organization, of which so far from there being an antecedent improbability there is a great probability, then there can be no question that all the subsequent ills mentioned are likely to follow. The important physiological change which takes place at puberty, accompanied, as it is, by so great a revolution in mind and body, and by so large an expenditure of vital energy, may easily and quickly overstep its healthy limits and pass into a pathological change, under conditions of excessive stimulation, or in persons who are constitutionally feeble and whose nerve-centres are more unstable than natural; and it is a familiar medical observation that many nervous disorders of a minor kind, and even such serious disorders as chorea, epilepsy, insanity, are often connected with irregularities or suppresion of these important functions.

In addition to the ill effects upon the bodily health which are produced directly by an excessive mental application, and a consequent development of the nervous system at the expense of the nutritive functions, it is alleged that remoter effects of an injurious character are produced upon the entire nature, mental and bodily. The arrest of development of the reproductive system discovers itself in the physical form and in the mental character. There is an imperfect development of the structure which Nature has provided in the female for nursing her offspring.

"Formerly," writes another American physician, Dr. N. Allen, "such an organization was generally possessed by American women, and they found but little difficulty in nursing their infants. It was only occasionally in case of some defect in the organization, or where sickness of some kind had overtaken the mother, that it became necessary to resort to the wet-nurse, or to feeding by hand. And the English, the Scotch, the German, the Canadian, the French, and the Irish women who are living in this country, generally nurse their children; the exceptions are rare. But how is it with our American women who become mothers? It has been supposed by some that all, or nearly all of them, could nurse their offspring just as well as not; that the disposition only was wanting, and that they did not care about having the trouble or confinement necessarily attending it. But this is a great mistake. This very indifference or aversion shows something wrong in the organization, as well as in the disposition; if the physical system were all right, the mind and natural instincts would generally be right also. While there may be here and there cases of this kind, such an indisposition is not always found. It is a fact that large numbers of our women are anxious to nurse their offspring, and make the attempt; they persevere for a while—perhaps for weeks or months—and then fail. . . . There is still another class that cannot nurse at all, having neither the organs nor nourishment necessary to make a beginning."

Why should there be such a difference between American women and those of foreign origin residing in the same locality, or between them and their grandmothers? Dr. Allen goes on to ask. The answer he finds in the undue demands made upon the brain and nervous system, to the detriment of the organs of nutrition and secretion:

"In consequence of the great neglect of physical exercise, and the continuous application to study, together with various other influences, large numbers of our American women have altogether an undue predominance of the nervous temperament. If only here and there an individual were found with such an organization, not much harm comparatively would result; but when a majority, or nearly a majority have it, the evil becomes one of no small magnitude."

To the same effect writes Dr. Weir Mitchell, an eminent American physiologist:

"Worst of all, to my mind, most destructive in every way, is the American view of female education. The time taken for the more serious instruction of girls extends to the age of eighteen, and rarely over this. During these years they are undergoing such organic development as renders them remarkably sensitive. . . . To-day the American woman is, to speak plainly, physically unfit for her duties as woman, and is, perhaps, of all civilized females, the least qualified to undertake those weightier tasks which tax so heavily the nervous system of man. She is not fairly up to what Nature asks from her as wife and mother. How will she sustain herself under the pressure of those yet more exacting duties which nowadays she is eager to share with man?"

Here, then, is no uncertain testimony as to the effects of the American system of female education: some women who are without the instinct or desire to nurse their offspring, some who have the desire but not the capacity, and others who have neither the instinct nor the capacity. The facts will hardly be disputed, whatever may finally be the accepted interpretation of them. It will not probably be argued that an absence of the capacity and the instinct to nurse is a result of higher development, and that it should be the aim of woman, as she advances to a higher level, to allow the organs which minister to this function to waste and finally to become by disuse as rudimentary in her sex as they are in the male sex. Their development is notably in close sympathy with that of the organs of reproduction, an arrest thereof being often associated with some defect of the latter; so that it might perhaps fairly be questioned whether it was right and proper, for the race's sake, that a woman who has not the wish or power to nurse should indulge in the functions of maternity. We may take note, by-the-way, that those in whom the organs are wasted invoke the dress-maker's aid in order to gain the appearance of them; they are not satisfied unless they wear the show of perfect womanhood. However, it may be in the plan of evolution to produce at some future period a race of sexless beings who, undistracted and unharassed by the ignoble troubles of reproduction, shall carry on the intellectual work of the world, not otherwise than as the sexless ants do the work and the fighting of the community.

Meanwhile, the consequences of an imperfectly developed reproductive system are not sexual only; they are also mental. Intellectually and morally there is a deficiency, or at any rate a modification answering to the physical deficiency; in mind, as in body, the individual fails to reach the ideal of a complete and perfect womanhood. If the aim of a true education be to make her reach *that*, it cannot certainly be a true education which operates in any degree to unsex her; for sex is fundamental, lies deeper than culture, cannot be ignored or defied with impunity. You may hide Nature, but you cannot extinguish it. Consequently, it does not seem impossible that, if the attempt to do so be seriously and persistently made, the result may be a monstrosity—something which having ceased to be woman is yet not man—"ce quelque chose de monstrueux," which the Comte A. de Gasparin forebodes, "cet être répugnant, qui déjà paraît à notre horizon."

The foregoing considerations go to show that the main reason of woman's position lies in her nature. That she has not competed with men in the active work of life was probably because, not having had the power, she had not the desire to do so, and because, having the capacity of functions which man has not, she has found her pleasure in performing them. It is not simply that man, being stronger in body than she is, has held her in subjection, and debarred her from careers of action which he was resolved to keep for himself; her maternal functions must always have rendered, and must continue to render, most of her activity domestic. There have been times enough in the history of the world when the freedom which she has had, and the position which she has held in the estimation of men, would have enabled her to assert her claims to other functions, had she so willed it. The most earnest advocate of her rights to be something else than what she has hitherto been would hardly argue that she has always been in the position of a slave kept in forcible subjection by the superior physical force of men. Assuredly, if she has been a slave she has been a slave content with her bondage. But it may perhaps be said that in that lies the very pith of the matter—that she is not free, and does not care to be free; that she is a slave, and does not know or feel it. It may be alleged that she has lived for so many ages in the position of dependence to which she was originally reduced by the superior muscular strength of man, has been so thoroughly imbued with inherited habits of submission, and overawed by the influence of customs never questioned, that she has not the desire for emancipation; that thus a moral bondage has been established more effectual than an actual physical bondage. That she has now exhibited a disposition to emancipate herself, and has initiated a movement to that end, may be owing partly to the easy means of intellectual intercommunication in this age, whereby a few women scattered through the world, who felt the impulses of a higher inspiration, have been enabled to coöperate in a way that would have been impossible in former times, and partly to the awakened moral sense, and to the more enlightened views of men, which have led to the encouragement and assistance, instead of the suppression, of their efforts.

It would be rash to assert that there is not some measure of truth in these arguments. Let any one who thinks otherwise reflect upon the degraded condition of women in Turkey, where habit is so ingrained in their nature, and custom so powerful over the mind, that they have neither thought nor desire to attain to a higher state, and "naught feel their foul disgrace:" a striking illustration how women may be demoralized and yet not know or feel it, and an instructive lesson for those who are anxious to form a sound judgment upon the merits of the movement for promoting their higher education and the removal of the legal disabilities under which they labor. It is hardly possible to exaggerate the effects of the laws and usages of a country upon the habits of thought of those who, generation after generation, have been born, and bred, and have lived under them. Were the law, which ordains that, when a father dies intestate, all the real property of which he is possessed shall be inherited by his eldest son, his other children being sent empty away, enacted for the first time, there is no one, probably, who would not be shocked by its singular injustice; yet the majority of persons in this country are far from thinking it extraordinary or unjust, and a great many of them would deem it a dangerous and wicked doctrine to question its justice. Only a few weeks ago, a statesman who has held high offices in a Conservative ministry, in an address to electors, conjured them not to part with the principle of primogeniture, and declared that there was no change in the law which he would so vehemently oppose as this: "Let them but follow the example of a neighboring nation in this respect, and there was an end of their personal freedom and liberty!" So much do the laws and usages of a country affect the feelings and judgments of those who dwell therein. If we clearly apprehend the fact, and allow it the weight which it deserves, it will be apparent that we must hesitate to accept the subordinate position which women have always had as a valid argument for the justice of it, and a sufficient reason why they should continue forever in it.

But may we not fairly assert that it would be no less a mistake in an opposite direction to allow no weight to such an argument? Setting physiological considerations aside, it is not possible to suppose that the whole explanation of woman's position and character is that man, having in the beginning found her pleasing in his eyes and necessary to his enjoyment, took forcible possession of her, and has ever since kept her in bondage, without any other justification than the right of the strongest. Superiority of muscular strength, without superiority of any other kind, would not have done that, any more than superiority of muscular strength has availed to give the lion or the elephant possession of the earth. If it were not that woman's organization and functions found their fitting home in a position different from, if not subordinate to, that of men, she would not so long have kept that position. If she is to be judged by the same standard as men, and to make their aims her aims, we are certainly bound to say that she labors under an inferiority of constitution by a dispensation which there is no gainsaying. This is a matter of physiology, not a matter of sentiment; it is not a mere question of larger or smaller muscles, but of the energy and power of endurance of the nerve-force which drives the intellectual and muscular machinery; not a question of two bodies and minds that are in equal physical conditions, but of one body and mind capable of sustained and regular hard labor, and of another body and mind which for one quarter of each month during the best years of life is more or less sick and unfit for hard work. It is in these considerations that we find the true explanation of what has been from the beginning until now, and what must doubtless continue to be, though it be in a modified form. It may be a pity for woman that she has been created woman, but, being such, it is as ridiculous to consider herself inferior to man because she is not man, as it would be for man to consider himself inferior to her because he cannot perform her functions. There is one glory of the man, another glory of the woman, and the glory of the one differeth from that of the other.

Taking into adequate account the physiology of the female organization, some of the statements made by the late Mr. Mill in his book on the subjection of women strike one with positive amazement. He calls upon us to own that what is now called the nature of women is an eminently artificial thing, the result of forced repression in some directions, of unnatural stimulation in others; that their character has been entirely distorted and disguised by their relations with their masters, who have kept them in so unnatural a state; that if it were not for this there would not be any material difference, nor perhaps any difference at all, in the character and capacities which would unfold themselves; that they would do the same things as men fully as well on the whole, if education and cultivation were adapted to correcting, instead of aggravating, the infirmities incident to their temperament; and that they have been robbed of their natural development, and brought into their present unnatural state, by the brutal right of the strongest which man has used. If these allegations contain no exaggeration, if they be strictly true, then is this article an entire mistake.

Mr. Mill argues as if, when he has shown it to be probable that the inequality of rights between the sexes has no other source than the law of the strongest, he had demonstrated its monstrous injustice. But is that entirely so? After all, there is a right in might—the right of the strong to be strong. Men have the right to make the most of their powers, to develop them to the utmost, and to strive for, and if possible gain and hold, the position in which they shall have the freest play. It would be a wrong to the stronger if it were required to limit its exertions to the capacities of the weaker. And if it be not so limited, the result will be that the weaker must take a different position. Men will not fail to take the advantage of their strength over women: are no laws, then, to be made which, owning the inferiority of women's strength, shall ordain accordingly, and so protect them really from the mere brutal tyranny of might? Seeing that the greater power cannot be ignored, but in the long-run must tell in individual competition, it is a fair question whether it ought not to be recognized in social adjustments and enactments, even for the necessary protection of women. Suppose that all legal distinctions were abolished, and that women were allowed free play to do what they could, as it may be right they should—to fail or succeed in every career upon which men enter; that all were conceded to them which their extremest advocates might claim for them; do they imagine that, if they, being in a majority, combined to pass laws which were unwelcome to men, the latter would quietly submit? Is it proposed that men should fight for them in war, and that they, counting a majority of votes, should determine upon war? Or would they no longer claim a privilege of sex in regard to the defense of the country by arms? If all barriers of distinction of sex raised by human agency were thrown down, as not being warranted by the distinctions of sex which Nature has so plainly marked, it may be presumed that the great majority of women would continue to discharge the functions of maternity, and to have the mental qualities which correlate these functions; and if laws were made by them, and their male supporters of a feminine habit of mind, in the interest of babies, as might happen, can it be supposed that, as the world goes, there would not soon be a revolution in the state by men, which would end in taking all power from women and reducing them to a stern subjection? Legislation would not be of much value unless there were power behind to make it respected, and in such case laws might be made without the power to enforce them, or for the very purpose of coercing the power which could alone enforce them.

So long as the differences of physical power and organization between men and women are what they are, it does not seem possible that they should have the same type of mental development. But while we see great reason to dissent from the opinions, and to distrust the enthusiasm, of those who would set before women the same aims as men, to be pursued by the same methods, it must be admitted that they are entitled to have all the mental culture and all the freedom necessary to the fullest development of their natures. The aim of female education should manifestly be the perfect development, not of manhood but of womanhood, by the methods most conducive thereto: so may women reach as high a grade of development as men, though it be of a different type. A system of education which is framed to fit them to be nothing more than the superintendents of a household and the ornaments of a drawing-room, is one which does not do justice to their nature, and cannot be seriously defended. Assuredly those of them who have not the opportunity of getting married suffer not a little, in mind and body, from a method of education which tends to develop the emotional at the expense of the intellectual nature, and by their exclusion from appropriate fields of practical activity. It by no means follows, however, that it would be right to model an improved system exactly upon that which has commended itself as the best for men. Inasmuch as the majority of women will continue to get married and to discharge the functions of mothers, the education of girls certainly ought not to be such as would in any way clash with their organization, injure their health, and unfit them for these functions. In this matter the small minority of women who have other aims and pant for other careers, cannot be accepted as the spokeswomen of their sex. Experience may be left to teach them, as it will not fail to do, whether they are right or wrong in the ends which they pursue and in the means by which they pursue them: if they are right, they will have deserved well the success which will reward their faith and works; if they are wrong, the error will avenge itself upon them and upon their children, if they should ever have any. In the worst event they will not have been without their use as failures; for they will have furnished experiments to aid us in arriving at correct judgments concerning the capacities of women and their right functions in the universe. Meanwhile, so far as our present lights reach, it would seem that a system of education adapted to women should have regard to the peculiarities of their constitution, to the special functions in life for which they are destined, and to the range and kind of practical activity, mental and bodily, to which they would seem to be foreordained by their sexual organization of body and mind.

NOTE.—It is fair to say that other reasons for the alleged degeneracy of American women are given. For example, a correspondent writes from America: "The medical mind of the United States is arrayed in a very ill-tempered opposition, on assumed physiological grounds, to the higher education of women in a continuous curriculum, and especially to that coeducation which some colleges in the Western States, Oberlin, Antioch, inaugurated twenty years ago, and which latterly Cornell University has adopted. The experience of Cornell is too recent to prove any thing; but the Quaker college of Swarthmore claims a steady improvement on the health of its girl-graduates, dating from the commencement of their college course; and the Western colleges report successful results, mentally, morally, and physically, from their coeducation experiment. Ignoring these facts, the doctors base their war-cry on the not-to-be-disputed fact that American women are growing into more and more of invalidism with every year. Something of this is perhaps due to climate. I will not say to food; for the American *menu*, in the cities at least, has improved since Mr. Dickens's early days, and has learned to combine French daintiness, very happily, with the substantial requirements of an English table.

"American men, as a rule, 'break down' between forty and fifty, when an Englishman is but beginning to live his public and useful life. The mad excitement of business you have, as well as we; so it must be the unrest of the climate, and their unphilosophical refusal of open-air pleasures and exercise, which are to blame in the case of the men.

"There are other reasons which go to make up the languid young-ladyhood of the American girl. Her childhood is denied the happy out-door sports of her brothers. There is a resolute shutting out of every thing like a noisy romp; the active games and all happy, boisterous plays, by field or roadside, are not *proper* to her! She is cased in a cramping dress, so heavy and inconvenient that no boy could wear it for a day without falling into gloomy views of life. All this martyrdom to propriety and fashion tells upon strength and symmetry, and the girl reaches womanhood a wreck. That she reaches it at all, under these suffering and bleached-out conditions, is due to her superior elasticity to resist a method of education which would have killed off all the boys years before. . . . There are abundant statistics to prove that hard study is the discipline and tonic most girls need to supplant the too great sentimentality and useless day-dreams fostered by fashionable idleness, and provocative of 'nerves,' melancholy, and inanition generally, and, so far as statistics can, that the women-graduates of these colleges make as healthy and happy wives and mothers as though they had never solved a mathematical problem, nor translated Aristotle."—*Fortnightly Review.*

NOSTALGIA.

By FERNAND PAPILLON.

TRANSLATED BY A. R. MACDONOUGH.

THOSE great changes of place, temporarily, by masses of people, which were brought about by the late war, have drawn the attention of physicians again to a very singular malady, nostalgia, or homesickness, some extremely noteworthy cases of which appeared, particularly among the *mobiles* collected at Paris during the siege. Indeed, homesickness is a real disease, occasioning a group of symptoms and disturbances of very definite character—a disease the more real, inasmuch as it often ends in death. An eminent physician, who had earlier opportunities as a health-officer in the navy, and lately again as chief of one of the great Paris ambulances, to study nostalgia very closely, Dr. Benoist de la Grandière, has published an essay on the subject which will give us some interesting facts.

Sauvage describes nostalgia by four words—*morositas*, *pervigilio*, *anorexia*, *asthenia*—which signify sadness, sleeplessness, want of appetite, and exhaustion. The patient very early loses his cheerfulness and vigor, and courts in solitude a surrender to the fixed idea that haunts him, the thought of his country. He dwells in charmed repetition upon the memories connected with the places where his early life was spent, and paints them with a world of dreams in which his imagination shuts itself so obstinately that nothing can call him away from it. He shuns the persons once loved best, rejects all diversions, and is angered by any attempt to console him. The conviction cherished by fancy that he shall never see his country again, and the grief it inspires, bring on disturbances of function which at last affect the whole natural system. His features change, his eyes grow set and dull, his countenance wears a look of stupor, his motions then grow languid, and betray painful indecision of will. Anæmia follows, the skin becomes dry and clammy, the mucous tissues lose color, the secretions decrease, the pulse sinks, and disturbance of the circulation appears. With regard to the digestive functions, the disorder is not less serious; as the patient eats little or nothing, gastric difficulties ensue. In women, chlorosis occurs, with its usual train of varied nervous affections; they neglect their dress and all their interests of emotion, including coquetry; then follow intermitting chills and night-sweats, making what Broussais called the hectic fever, and Larry the dry consumption of the melancholy-mad. At length the intellect and the patient perish together, with a last sigh for the country never again to be seen. The chief and peculiar mark of this neurosis is that the sufferer knows he must die. It often happens that nostalgic patients voluntarily starve to death or commit suicide.

Nostalgia attacks by preference young people and those just entering youth, affecting all temperaments without distinction. It is oftenest remarked among soldiers. During the great wars of the Revolution and the Empire it often prevailed as an epidemic, and scourged our armies with severity. Desgenettes relates that at St.-Jean-d'Acre it added a new complication and a more fatal horror to the plague. On the pontoons at Cadiz and Plymouth, that served as prisons for the soldiers of General Dupont, after the capitulation of Baylen, it killed as many French as died from yellow fever. In Poland and in Russia it intensified all other epidemic disorders. Michel Lévy says that in 1831 the Twenty-first regiment of light infantry, then in the Morea, received a large number of young Corsican recruits, many of whom fell victims to nostalgia, in the hospital at Navarino.

During the last war nostalgia carried off many sufferers among our unhappy prisoners dispersed throughout Germany. It attacked the soldiers and *mobiles* during the siege of Paris, especially toward the close of it, when privations and successive defeats began to reduce the most robust organizations. Many of the cases of nostalgia then observed in the hospitals and ambulances presented a really piteous sight. One instance we personally saw. The 4th of January, 1871, the young Marquis R——, aged twenty-four, a *mobile* from Finisterre, entered the Bicêtre military hospital. He had a slight varioloid and a bronchial complaint, which were certain to be cured, and actually were so. Yet this illness gave him slight concern; he was the victim of other anxieties. He ate hardly any thing, and spent his time in tears and prayers, refusing all efforts to distract or console him. On the 10th of

January all symptoms of disease had disappeared, but his emaciation had so increased, and the sinking of his moral force was so alarming, that the house-physician thought it his duty to remonstrate kindly with him. Two soldiers and a nurse were placed in attendance on him, who talked with him constantly in the Breton dialect, about his country and his family. All these methods failed. On the 16th, when examined again by the physician, the young patient sighed sadly, and, with tears in his eyes, expressed himself nearly in these words: "It is all over; I am very sure of it; I am going to die, and you will not succeed in preventing it. I had never left Brittany; I was satisfied, rich, and happy; my father died without ever having been severe with me, leaving me always to do as I chose. I refused to go to college, and was educated at home; I grew up under the curé's training and instruction, and led the careless, pure, and honorable life of a Breton gentleman. Who would have told me that I should ever leave Finisterre, and come to die in a hospital-bed at the gates of Paris! I was sure of it, the day I left Brittany, that it was all over with me. I was at Villiers, at Champigny—I fought there, doing as the rest did, but God refused to take me. He chose to try me yet more, and I bow to his holy will. If you knew how I suffer! Never to see my mansion again, nor the forests, nor my flocks, my horse, and my dogs! May God shorten my misery, and pardon my weakness! How loud the guns sound this morning!—the building will be battered down—do not stay here—my last hour is near, and I wish to make ready for death as a good Christian." The 23d of January the patient's pulse was at 110, his skin dry, his eye brilliant, his mind wandering, and on the 28th, at ten in the morning, he died.

Benoist de la Grandière gives some curious details about nostalgia in different nations. The French, precisely because they are more attached to their country than any others, and feel a passionate aversion to expatriation, are the very ones whom nostalgia most readily attacks. The inhabitants of the western departments, particularly the Bretons, and next to them those of the southern provinces and of Corsica, are remarkably predisposed to it. The very religious life, the manners so unchanging and the customs so characteristic which have continued so long in Brittany, create bonds not to be severed without danger between the soil of ancient Armorica and its inhabitants. The Swiss, too, love their country warmly, and never quit it but with regret. Nostalgia is not uncommon in Italy, particularly since the transfer of conscripts from one end of the kingdom to the other has become the practice. Between 1867 and 1870, the Italian Army showed a total of 203 cases of positive nostalgia, eight of which were fatal. The English and the Germans leave their country with less reluctance. The English, above all, are spared nostalgia through their adventurous spirit, and it may be said that their country is wherever the British flag floats. The cosmopolitan character of the Germans is less positive. During the late war, nostalgia found quite a number of victims among the soldiers of the Landwehr; and, on a late journey to Alsatia, I satisfied myself that it affected the soldiers from Silesia and Pomerania.

Sagar says that love of country is strongest with those who are nearest to a state of nature. This is quite correct. Savages, men living under the rudest forms of civilization, in the most uninviting climates, grieve when they quit them. Foissar relates that a Lapp, brought to Poland, where every kindness was shown him, was seized with incurable sadness, and at last escaped and returned to his inhospitable country. Greenlanders who had been taken across to Denmark, risked certain death by trusting themselves to slight canoes to cross the ocean separating them from their own land. Similar facts have been observed among the North American Indians. Albert mentions the story of a young squaw, Couramé, a foundling in the forest, adopted by a rich family. "Take me back," she exclaimed, "take me back to the land where I was born. O mother! have you quite forgotten me?" Couramé fell ill, and wasted away. One day, falling in with some Indians of her tribe, she made her escape with them. Strange affinity! that unconquerable attachment of man to the soil, the climate, the aspect of the narrow-bounded region in which his childhood had been spent! What an argument to oppose to our international and humanitarian philosophers!

What, then, is this strange disease? Most physicians class it as a variety, one form, of insanity, a sort of mania or melancholy. Benoist de la Grandière does not so regard it; he discovers in it a nervous affection of the organs through which imagination and memory act. The very clear distinctions which he points out between nostalgia and other kinds of mental derangement justify his way of viewing it. Indeed, the nostalgic patient has no such senseless or extravagant notions as madmen have. He never fancies himself possessed of a devil, or changed to a wolf or a dog. He is not swayed, as are the melancholy-mad, by the dread or terror of some imagined ill. On the other hand, the subjects of mania, or hypochondria, are usually in good health; in spite of their deranged intellects, they retain their strength and good condition. The deep sadness of the nostalgic patient, on the contrary, produces its first effect by changing the functions of nutrition in him, and causing disturbances that are often fatal to life. The various conditions of insanity are hereditary, while nostalgia never is so. Besides, the especial characteristic of this disorder is that it may be cured with absolute certainty, when the troubles it has brought about have not yet endangered the health; restoring the patient to his family effects a complete cure. On the contrary, the attempt to satisfy an ambitious madman's dreams of greatness or of wealth, far from lessening his mental derangement, will only give it new violence.

Whatever the nature of it, there is but one way to cure the unhappy creature whom love of his country consumes and destroys, and that is to send him back to his own land. Where that remedy is not possible, and fortunately that is not often the case, the medical treatment of nostalgia is limited merely to moral and hygienic palliatives. The very first duty of physicians, whenever the causes of nostalgia seem threatening, is to adopt preventives of its fatal influence. With this object, it is essential to employ actively and to divert in all possible ways soldiers and sailors who are taken to a distance from their country. It seems to be settled, moreover, that nostalgia is far less common in the navy than among the land-forces, and the fact probably depends upon the careful attention with which officers of the navy exert themselves to provide for the amusement of sailors, and to guard them against *ennui.* Nothing is so gay as a vessel's crew. Discipline does not suffer by it, and obedience is only the more prompt. "A ship without singing aboard," says Foussagrives, "always leads us to suspect the moral government it is kept under." During the Chinese campaign, on board the Forbin, whose crew was entirely made up of Bretons, all important manœuvres were gone through with to the accompaniment of the national *biniou.*

In the case of nostalgic patients whose illness results from the isolation they are reduced to by the language they speak, association with people who speak the same tongue is often one of the most effectual remedies. Esquirol, remarking that all the Bretons placed in one of the halls of the Salpêtrière showed more serious symptoms than patients occupying beds in the other wards of the hospital, directed students from Brittany to be stationed in that hall, requesting them to talk in a friendly way in their native dialect with their compatriots. No other treatment was needed for the cure of nostalgic cases. During the siege of Paris similar facts often occurred. In the ambulances, countrymen, particularly Bretons, were remarked growing perceptibly thinner and weaker. The physicians questioned them but got no answers, as they understood only their provincial dialect. Some one was found at length who could talk with them in that dialect, console them, and cheer them up, and the poor wretches visibly regained strength and hope. When all expedients have failed, and circumstances forbid the patient's return to his own country, there are still devices of stratagem that may improve his case. During the investment of Mayence the physicians sent word to the soldiers swept off by typhus and nostalgia that the general-in-chief had obtained from the besiegers a free passage for convalescents. The hope revived the courage of many among these unfortunates. Marceray cured a monk employed in a military hospital by making him read a fictitious letter containing permission from his superior to return before long to his convent. The case is the same with nostalgia as with other nervous affections, in which drugs are almost wholly powerless, and no improvement can be expected from other means than from skillful and judicious moral intervention on the physician's part.—*Revue des Deux Mondes.*

NOTE, BY THE EDITOR OF THE REVUE.—Circumstances have prevented the earlier publication of the foregoing sketch, which has been for some time in our possession. It is the last one sent us by one of our most sympathetic fellow-laborers, whom death removed suddenly and prematurely from his friends, the 2d of January, at the age of twenty-six.

THE ATMOSPHERE AS AN ANVIL.[1]

BY PROFESSOR J. P. COOKE, JR.

THE office of the atmosphere, as an anvil upon which rocks are shattered for the protection of humanity, has sufficient novelty about it to require explanation. It has come to be pretty well understood now that rocky fragments of all sizes are flying through space, like the planets themselves. What the effect would be, if hard meteoric stones were to strike, with a velocity sixty times as great as that of a cannon-ball, the structures that man builds upon earth, it is not difficult to imagine. To say nothing of the larger stones, no ordinary buildings could afford shelter from the smallest particles striking with the velocity of eighteen miles per second. Even dust flying at such a rate would kill any animal exposed to it. How effectually we are guarded by the atmosphere, as with a shield, impenetrable in proportion to the violence of the assaults upon it, is admirably illustrated by Prof. Cooke in the following statement, condensed from Chapter X. of his "New Chemistry:"

"Within a few years our community have become familiar with the name and terrible effects of a new explosive agent, called nitro-glycerine, and I feel sure that you will be glad to be made acquainted with the remarkable qualities and relations of this truly wonderful substance. Every one knows that clear, oily, and sweet-tasting liquid called glycerine, and probably most of you have eaten it for honey. But it has a great many valuable uses, which may reconcile you to its abuse for adulterating honey, and it is obtained in large quantities, as a secondary product of the manufacture of soap and candles, from our common fats. Now, nitro-glycerine bears the same relation to glycerine that saltpetre bears to caustic potash. Common saltpetre, which is the oxygenated ingredient of gunpowder, is called in chemistry potassic nitrate, and, although the commercial supply comes wholly from natural sources, it can easily be made by the action of nitric acid on

[1] Condensed from "The New Chemistry," Chapter X., "Gunpowder and Nitro-Glycerine."

caustic potash. My assistant will pour some nitric acid into a solution of caustic potash, and you will soon see crystals of saltpetre appear, shooting out from the sides of the dish, whose image we have projected on the screen. In a similar way we can prepare nitro-glycerine, by pouring glycerine in a fine stream into very strong nitric acid, rendered more active by being mixed with sulphuric acid—oil of vitriol.

"We could easily make the experiment, but you could see nothing. There is no apparent change, and it is a remarkable fact that, when pure, nitro-glycerine resembles, externally, very closely glycerine itself, and, like it, is a colorless, oily fluid—the reddish-yellow color of the commercial article being due to impurities. As soon as the chemical change is ended, the nitro-glycerine must be very carefully washed with water, until all adhering acid has been removed. The material thus obtained has most singular qualities, and not the least unexpected of these is its stability under ordinary conditions. After the terrible accidents that have happened, it would, perhaps, be rash to say that it did not readily explode; but I can assure you that it is not an easy matter to explode pure nitro-glycerine. It is not nearly so explosive as gunpowder, and I am told that the flame of an ordinary match can be quenched in it without danger, although I confess that I should be unwilling to try the experiment. Still, there can be no doubt that, under ordinary circumstances, a small flame will not ignite it. My knowledge of the matter is derived from Prof. Hill, of the Torpedo Station, at Newport, who has studied very carefully the preparation and application of the material. He is of opinion that most of the accidents which have given to nitro-glycerine such an unfortunate notoriety have been caused by the use of an impure article, and that proper care in its preparation would greatly lessen the danger attending its use. Nitro-glycerine is usually exploded, not by the direct application of heat, but by a sudden and violent concussion, which is obtained by firing in contact with it a fuse of some fulminating powder. The effects of this explosion are as peculiar as the method by which it is obtained, and I can best illustrate the subject by describing an experiment with nitro-glycerine which I witnessed myself at the Torpedo Station a few months since.

"It is so inconvenient to handle liquid nitro-glycerine that it is now usual to mix it with some inert and impalpable powder, and the names dualine and dynamite have been given to different mixtures of this kind; but in both of these the powder merely acts as a sponge. In the experiment referred to, a canister holding less than a pound of dynamite, and only a few ounces of nitro-glycerine, was placed on the top of a large bowlder-rock, weighing two or three tons. In order that you may fully appreciate the conditions, I repeat that this tin case was simply laid on the top of the bowlder, and not confined in any way. The nitro-glycerine was then exploded by an appropriate fuse fired from a distance by electricity. The report was not louder than from a heavy gun, but the rock on which the canister lay was broken into a thousand fragments.

"This experiment strikingly illustrates the peculiar action of nitro-glycerine. In using gunpowder for blasting, it is necessary to confine it, by what is called tamping, in the hole prepared for it in the rock. Not so with nitro-glycerine. This, though it may be put up in small tin cartridges for convenience, is placed in the drill-holes without tamping of any kind. Sometimes the liquid itself has been poured into the hole, and then a little water poured on the top is the only means used to confine it. As an agent for blasting, nitro-glycerine is so vastly superior to gunpowder, that it must be regarded as one of the most valuable discoveries of our age. Already it is enabling men to open tracks for their iron roads through mountain-barriers, which, a few years ago, it would have been thought impracticable to pierce, and, although its introduction has been attended with such terrible accidents, those best acquainted with the material believe that, with proper care in its manufacture, and proper precautions in its use, it can be made as safe as or even safer than gunpowder, and the Government can do no better service toward developing the resources of the country than by carrying forward the experiments it has instituted at the Torpedo Station at Newport, until all the conditions required for the safe manufacture and use of this valuable agent are known, and, when this result is reached, imposing on the manufacturers, dealers, and carriers, such restrictions as the public safety requires. Of course, we cannot expect thus to prevent all accidents. Great power in the hands of ignorant or careless men implies great danger. Sleepless vigilance is the condition under which we wield all the great powers of modern civilization, and we cannot expect that the power of nitro-glycerine will be any exception to the general rule.

"But, while nitro-glycerine has such great rending power, it has no value whatever as a projectile agent. Exploded in the chamber of a gun, it would burst the breech before it started the ball. Indeed, there is a great popular misapprehension in regard to the limit of the projectile power of gunpowder, and inventors are constantly looking for more powerful projectile agents as the means of obtaining increased effects. But a study of the mechanical conditions of projection will show not only that gunpowder is most admirably adapted to this use, but also that its capabilities far exceed the strength of any known material, and the student will soon be convinced that what is wanted is not stronger powder, but stronger guns. I do not mean to say that we cannot conceive of a better powder than that now in use, but merely that its shortcoming is not want of strength.

"In gunpowder the grains of charcoal and nitre, although very small, have a sensible magnitude, and consist each of many thousand if not of many million molecules. The chemical union of the oxygen of the nitre with the carbon-atoms of the charcoal can take place only on the surface of charcoal-grains; the first layer of molecules must be consumed before the second can be reached, and so on. Hence the process, although very rapid, must take a sensible time. In the nitro-glycerine, on the other hand, the two sets of atoms, so far from being in different grains, are in one and the same molecule, and the internal combustion is essentially instantaneous. Now, this element of time will explain a great part of the difference in the effect of the two explosions, but a part is also due to the fact that nitro-glycerine yields fully nine hundred times its volume of gas, while with gunpowder the volume is only about three hundred times that of the solid grains. There is a further difference in favor of the nitro-glycerine in the amount of energy liberated, but this we will leave out of account, although it is worthy of notice that energy may be developed by internal molecular combustion as well as in the ordinary processes of burning.

"The conditions, then, are these: With gunpowder we have a volume of gas, which would normally occupy a space three hundred times as great as the grains used, liberated rapidly, but still in a perceptible interval. With nitro-glycerine a volume of gas, nine hundred times that of the liquid used, is set free, all but instantaneously. Now, in order to appreciate the difference of effect which would follow this difference of condition, you must remember that all our experiments are made in air, and that this air presses with an enormous weight on every surface. If a volume of gas is suddenly liberated, it must lift this whole weight, which, therefore, acts as so much tamping material. This weight, moreover, cannot be lifted without the expenditure of a large amount of work. Let us make a rough estimate of the amount in the case of nitro-glycerine. We will assume that in the experiment at Newport the quantity exploded yielded a cubic yard of gas. Had the air given way instead of the rock, the liberation of this volume of gas must have lifted the pressure on one square yard (about nine tons) one yard high, an amount of work which, using these large units, we will call nine yard-tons, or about sixty thousand foot-pounds. Moreover, this work must have been done during the excessively brief duration of the explosion, and, it being less work to split the rock, it was the rock that yielded, and not the atmosphere. Compare now, the case of gunpowder. The same weight of powder would yield only about one-third of the volume of gas, and would, therefore, raise the same weight to only one-third of the height; doing, therefore, but one-third of the amount of work, say twenty thousand foot-pounds. Moreover, the duration of the explosion being at least one hundred times longer than before, the work to be done in lifting the atmosphere during the same exceedingly short interval would be only $\frac{1}{100}$ of twenty thousand foot-pounds, or two hundred foot-pounds, and, under these circumstances, you can conceive that it might be easier to lift the air than to break the rock.[1] . . . . .

[1] We here omit, for want of space, the beautiful explanation, afforded by the "New

"If there are some who have not followed me through this simple calculation, they may, perhaps, be able to reach clear views upon the subject by looking at the phenomena in a somewhat different way. It can readily be seen that the sudden development of this large volume of gas, which becomes at once a part of the atmosphere, would be equivalent to a blow by the atmosphere against the rock; or, what would be a more accurate representation of the phenomenon, since the air is the larger mass, and acts as the anvil, a blow by the rock against the air. It may seem very singular that our atmosphere can act as an anvil, against which a rock can be split, and yet it is so, and, if the blow has velocity enough, the atmosphere presents as effective a resistance as would a granite ledge. The following consideration will, I think, convince you that this is the case: I have here a light wooden surface, say, one yard square; the pressure of the air against the surface is equal, as I just stated, to about nine tons; but the air presses equally on both sides, and the molecules have such great mobility that, when we move the surface slowly, they readily give way, and we encounter but little resistance. If, however, we push it rapidly forward, the resistance greatly increases, for the air-molecules must have time to change their position, and we encounter them in their passage. If, now, we increase the velocity of the motion to the highest speed ever attained by a locomotive—say, one and one-fifth mile per minute—we should encounter still more particles, and find a resistance which no human muscle could overcome. Increase that velocity ten times, to twelve miles a minute, the velocity of sound, and the air would oppose such a resistance that our wooden board would be shivered into splinters. Multiply again the velocity ten times, and not even a plate of boiler-iron could withstand the resistance. Multiply the velocity once more by ten, and we should reach the velocity of the earth in its orbit, about twelve hundred miles a minute, and, to a body moving with this velocity, the comparatively dense air at the surface of the earth would present an almost impenetrable barrier, against which the firmest rocks might be broken to fragments. Indeed, this effect has been several times seen, when meteoric masses, moving with these planetary velocities, penetrate our atmosphere. The explosions which have been witnessed are simply the effect of the concussion against the aëriform anvil at a point where the atmosphere is far less dense than it is here. So, in the case of the nitro-glycerine, the rock strikes the atmosphere with such a velocity that it has the effect of a solid mass, and the rock is shivered by the blow."

Chemistry," of the molecular constitution of nitro-glycerine, and the transformations in its combustion, which account for the terrific force of its explosion.—Ed.

CREMATION AND ITS ALTERNATIVES.

By GEORGE BAYLES, M. D.

A SUBJECT upon which much earnest thought is concentred is, that method of disposing of the dead which shall be in strict accord with Nature's fixed intentions, and which shall not be delayed, by artificial means, to the obvious detriment of our plainest sanitary necessities. The only legitimate approach to a fair investigation of this subject is by the broad sanitary road. The obstacles are numerous and very serious by any other line of approach. There is a mountain of sentiment, of a very pronounced kind, on one side; a very formidable barrier of custom on the other; a rugged declivity of superstition in another direction, and a quagmire of indifference in another. To level all opposition of reason, prejudice, and superstition, is the work of the sanitarian. The chief appeal must be to that potent and first law of Nature, *self-protection;* and that law must be so proclaimed that, finally, a wholesome conviction shall take root in the popular mind that the sanitarian is right, and that every thing of a purely ethical and sentimental nature must yield to sounder views and practices than now prevail. This is, then, the true pathway to the right understanding of this subject.

Like all great reforms that have had their conception, their struggle for existence, and their ultimate triumph, any reform that contemplates so radical a change in the treatment of the beloved and respected dead is a work of time, and depends wholly upon an enlightened conception of the subject for its general recognition and popular development.

The placid, benign, and often spiritualized features of the recent dead, doubtless constitute a grave standing-ground of protest against the immediate reduction of the body to the dust and ashes to which the Almighty fiat has condemned it. There is something that savors of more than ignorant superstition in the commonly observed solemn hush in the presence of the body whose spirit has fled, in the super-delicate handling of the corpse by loving survivors, though with these manifestations of affection alone no sympathetic spirit would be inclined to quarrel. The scientific protest is not against the tribute of respect bestowed by sorrowing friends, let it be expressed in ever so many and ofttimes grotesque ways, while the body remains among the living, but, as it can so remain only a very brief period, the scientific protest is against all that in our modern times and civilized communities follows the social leave-taking of the dead.

No available progress can be made in moulding public taste and opinion upon this subject until scientific men are prepared to offer some economical and effectual method which shall be decorous and quick for reducing the body to the minimum of material bulk—in a word, to ashes or dust. No methods yet advanced and advocated could be of universal adaptability, for the one simple reason, if no other, that they have highly-technical features of manipulation that could not commonly be commanded. The great problem will be how to make the reduction at once a funeral ceremonial, rapid in execution, and very commendable to those who are bereaved by death. It is especially noticeable that the popular ideas have insensibly gravitated toward the burning of the dead, as the only sure and perfect method of consuming the mortal remains. It is also especially noticeable that cremation, though not without a very ancient history, has never been perfected as a process for the reduction of animal bodies to ashes. Such specimens as I have seen, after repeated experiments by this method, have not been ashes, but cinders and scraggy clinkers. Neither were they generally white, but gray and discolored. Even in ancient times, descriptions of the "*assilegium*," or gathering of the bones and ashes, also washing, anointing, and depositing them in urns, prove how imperfectly the combustion and calcination had been effected.

Dr. Brunetti's failure to burn the human body, after many hours of earnest effort, and a resort to breaking, by mechanical force, the bones and other hardened tissues, evidently inspired Prof. Reclam, of the Leipsic University, with a determination to solve this seemingly difficult problem. His efforts were rewarded with success. The body was perfectly consumed, by heat alone, in twenty minutes, at a cost of less than three dollars, though the apparatus, of course, was expensive. An approved apparatus would, however, serve an indefinite number of cases.

In the interests of sentiment, personal preferences, and economy, why might not scientific men suggest other ways of reducing the dead body than by means of fire? Has modern chemistry no resources? Have our electrologists no practical ideas to present? Why could there not be a lithological transformation of the dead, and a subsequent aqueous or chemical dissolution? Why may there not be a system of thorough desiccation, and subsequent pulverization?

Now, for the sake of illustrating our idea of a lithological transformation, suppose we were to submit a body to such chemical action as would convert it into one of the compounds of carbon; say, for instance, carbonate of calcium, or carbonate of magnesium, or possibly one of the hydrated compounds of carbon with calcium or magnesium. Of course, our product, if it were a carbonate of calcium, for instance, would bear some relation and resemblance to calc-spar, marble, limestone of various kinds, and chalk; also the substance of egg-shells, the shells of mollusks, and (with the addition only of a trace of phosphorus), to the bones of our body. Thus, the whole mass of structural tissues would be practically ossified. If it were a hydrocarbonate of magnesium, one product would be analogous (of course, not quite the same) to our magnesia alba of commerce. The formation of a mass of carbonate of calcium, not, however, possessing any degree of chemical purity worthy of mention, but sufficient for a specific mineralogical identification, and for the purpose of easy reduction to atoms by pulverization, deliquescence, or solution, would not be a difficult, expensive, or very tedious operation for the practical chemist. The reduction of the mass of carbonate of calcium into lime, and carbonic anhydride, would be a matter of the very easiest execution. It requires only heat to full redness in open vessels. In a current of air, or any gas, and especially of steam, the decomposition, or retrograde transition, takes place at a lower temperature. It requires no alteration of the principle in confining the process to the magnesium carbonates, or any other compound of carbon that may be mentioned. The hydrated carbonate, or ortho-carbonate, would differ from the carbonate less in principle than in the stage or point of extension of the process, and would be even more serviceable for one specific purpose, inasmuch as the product, at the ordinary temperature of the air, would crumble to a white powder, or, if quickly heated, would be converted into a pasty mass, which dries up to a powder. To effect this conversion of the body, which, at the outset of the operation, possesses the carbon element in sufficient abundance to be capable of almost any definite union under favorable circumstances, would require immersion in solutions which it would be easy to formulate and prepare, for any one under the inspiration of chemical experience and practical genius.

In a body weighing 154 pounds, not less than 110 pounds are water. Water, in any appreciable quantity, not becoming a constituent of our imagined *necro-lithos*, we see, at once, what an enormous reduction of bulk and actual weight the proposed process experiences. Therefore, no cognizance need be taken of the water of the body as a factor requiring special attention, its elimination being inevitable, and all the better, for it would have to be driven off by heat and evaporation, if it did not withdraw itself spontaneously. One of the peculiar features of the method is necessarily the spontaneous exclusion of the water—44 pounds of solid matter, then (in a body weighing 154 pounds), is exchanged for 44 pounds of calcareous stone of so non-compact a nature that it is peculiarly friable, peculiarly soluble, and wonderfully easy to dispose of. Carbon and water (or the elements of water), together with nitrogen, constitute about 98 per cent. of the whole weight of the human bedy. The nitrogen present weighs about 3½ pounds in 154, and to this is largely due the usual rapid decomposition. The suggested process of calcification would drive off nitrogen, together with about ten other very common chemical elements, existing in small quantities. The elements thus expelled rearrange themselves into ammonia, nitric acid, and other soluble substances, and disperse themselves through the air, and fall to the soil for its enrichment.

The pith of the whole matter is this: Cannot the dead body be, by some chemical process, metamorphosed into stone, and then reduced to powder, for preservation, like ashes, in the funeral-urn, or scattered to the winds of heaven, to seek its normal starting-point for future transitions?

A NEW PROCESS FOR THE PRESERVATION OF WOOD.

By M. A. HATZFELD.

THE question of the preservation of wood, applied to the sleepers of railroads, telegraph-poles, and wood for mechanical purposes, etc., becomes from day to day more urgent, in presence of the increase of railways. Of all the materials employed until now, there remain hardly two in use—sulphate of copper and creosote.

The sulphate of copper gives only imperfect and very variable results. This we can easily understand: this very soluble salt must be in part diluted by rain-water and the humidity of the soil, so that, at the end of a certain time, the preservative effect has disappeared. Besides, this process very often causes alteration in the wood from the impurity of the salt employed, or from its acid reaction—circumstances which it is very difficult to avoid, when we operate on a large scale with materials containing, in a state of combination, an energetic acid, having for its base a metalloid, such as chlorine, sulphur, nitrogen, etc.

As to creosote, it is a substance comparatively rare, of a high price, of an inflammable nature, and, in consequence, difficult to transport and handle. Besides, and this perhaps is the most important consideration, it is a product which, like those we extract from fossil-coal, may, some day or other, in consequence of a discovery analogous to that of aniline, acquire a high industrial value. Its employment would then become impossible for the preservation of wood.

Hence we may say that these two substances do but imperfectly comply with the necessary conditions, and the question arises, whether there is no other material that might be used in all our present yards, i. e., that might be injected equally well by Boucherie's process (gravitative force of a heavy column of liquid), and by the modified process of Bréant (successive action, in a close tank, of a vacuum and of a pressure of several atmospheres). I propose the acid tannate of protoxide of iron, and base my views on the following considerations:

Wood, as we know, consists of cellulose, or cells in which there is gradually deposited, as the timber matures, lignine, a hard concretion which makes up the greater part of the volume in hard woods, such as ebony, guaiacum, oak; in knots, the shells of nuts, etc. Wood, further, contains sap, which holds in suspension gummy materials, nitrogenous and albuminous substances, coloring-matters, etc.; these are the elements of decay in wood. Inasmuch as they offer to animal and plant-parasites an abundance of agreeable food, they undergo decomposition more or less rapidly, determining, by their own decay, the decay of all the other elements of the wood.

If we succeed in expelling these essentially putrescible materials, or fixing them in unalterable combinations, we thus prevent their decomposition, and, in consequence, that of the other more resistant organic substances, cellulose and lignine. A certain number of observed facts seem to demonstrate that the action of tannin upon vegetable tissues must be analogous to that which is exercised upon animal tissues—operating in the vegetable tissues a kind of tanning, which will have for result the formation of hard and imputrescible albuminous tannates, quite analogous to the gelatinous tannate products in the tanning of skins.

Thus, the sizing of wines is effected as well with the white of an egg (albuminous matter) as by isinglass (gelatinous matter). The tannic acid contained in the wine forms with either of these materials a solid net-work, which envelops and precipitates the lees to the bottom of the cask. An infusion of oak-bark preserves the skins of animals, and is also employed to protect from rotting the nets of hunters and fishermen. In fine, among exotic or indigenous woods, soft or hard, the most resistant are the richest in tannic acid, as among indigenous woods the oak and the chestnut; the first remarkably hard, the second soft enough, are both preserved during many years, and we cannot doubt that this is owing to the influence of the tannic acid with which they are impregnated, which, after the cutting of the wood, reacts upon the azotic and albuminous materials contained in their capillary vessels. We may therefore conclude that the injection of a solution of tannic acid into the various species of woods will assure their preservation, by putting them, in a chemical point of view, in conditions analogous to those in which we find the oak after it has been felled.

But it is not enough to protect soft wood from rotting; it must also be hardened; and though by the action of tannic acid we in some measure attain this end, the soft materials in the sap-vessels being transformed, still it is important that we should give to woods that are naturally soft a higher degree of hardness, in order to fit them for industrial uses.

I accomplish this object by the intervention of the remarkable property of tannate of iron, which, *perfectly soluble*, and even colorless, in a state of protoxide, is, under the influence of air, transformed into an insoluble salt, of an intense black color. Dissolved in tannic acid to the condition of a soluble salt, in proportions which vary according to the degree of hardness to be given to the wood, it is rapidly transformed under the influence of air, and is deposited in the cells of the wood in a solid state, which it petrifies, so to speak, thus increasing the preservative effects of the tannic acid.

Thus we find resolved, in a manner simple and practical, the question of the introduction of an insoluble salt into wood. We may operate by injecting successively tannic acid, and then a soluble salt of iron; or, by means of a single operation, inject, sheltered from the air, the tannate of protoxide of iron, prepared in advance.

Results of experiments demonstrate the efficacy of this system. In fact, we frequently find in ferruginous soils very old oaks of a black color, and in a state of perfect preservation. I will cite an example that is quite remarkable.

In 1830 there were found at Rouen pieces of oak-wood, from some piles of a bridge built in the year 1150. This wood resembles ebony, of which it has acquired the hardness and the color. Chemical analysis has demonstrated that this modification was owing to the presence of tannate of peroxide of iron (Berthier). Argument and experience, therefore, agree in deciding in favor of the process which I propose.

The bark of most trees, the young branches and leaves, especially of the oaks, birches, elms, sumacs, chestnuts, and walnuts, the roots of the tormentil, and snake-weed, the green shells of horse-chestnuts, and the extracts of exotic woods, contain a large proportion of tannin, to which they owe their astringent properties.

The First Cost of the Materials used for Injection.—In the present state of industry, we can procure tannin at one franc, at most, per kilogramme, in the form of extracts of wood that are employed in dyeing; but we may remark that these products, employed now only for dyeing and tanning, utilize only a very small quantity of the resources of the vegetable kingdom. There is no doubt that a considerable consumption of this product would lead to the establishment of numerous factories, principally in the poor regions, where chestnut and other suitable kinds of trees occur. The industrial wealth of the country would thus be augmented, and, at the same time, the price of this new product would be considerably reduced. Even at the present price, six hundred grammes being sufficient for the injection of one sleeper, the cost of the tannic acid would not exceed $\frac{60}{100}$ of a franc per sleeper. As to the salts of iron, they are so low in price that it is hardly worth while to estimate their cost. The salts of the protoxide of iron, soluble in tannic acid, carbonate, sulphate, protochloride, and pyrolignite, are easily procured or prepared. The pyrolignite, which seems the most convenient, is worth twenty francs the hundred kilogrammes, and, at a standard of 20° Baumé, contains about seven per cent. of iron. Of this, tannic acid neutralizes twelve per cent. of its own weight, and, if we adopt, for the normal product to inject, $\frac{4}{5}$ of tannic acid and $\frac{1}{5}$ of tannate of protoxide of iron, the cost would amount to from $\frac{5}{100}$ to $\frac{6}{100}$ of a franc, making, in all, an expense of $\frac{65}{100}$ of a franc per sleeper.

Trials of this process are at this moment in course of execution upon a grand scale, by the Railway Company of the East, and the Administration of the National Telegraphs, with the authority and coöperation of the Minister of the Interior.—*Comptes Rendus.*

SKETCH OF PROFESSOR HELMHOLTZ.

By G. A. F. VAN RHYN.

GERMANY assembled in 1869 her greatest *savants* to celebrate the centenary anniversary of the birth of Alexander von Humboldt, her greatest dead. The highest honor of this occasion was bestowed on Prof. Helmholtz, who delivered the opening oration. He reviewed the progress made in the natural sciences with special reference to the labors of German students, and said: "In Germany there has always been a greater fearlessness of the consequences resulting from speaking the whole truth than anywhere else. The eminent *savants* of England and France are still obliged to bow to the dictates of social and ecclesiastical prejudices, and, when they speak openly, they do it to the injury of their social standing. Germany is bolder; she confides in what has never proved false—that the whole truth is the best remedy for the evils of truth imperfectly stated."

The Academy of France lent new force to his statement by refusing to elect him a corresponding member, on account of the advanced ideas connected with his name. A French critic rebuked his countrymen for hesitating to bestow on Helmholtz, the greatest living physicist of this century, so slight an honor, with the remark: "For his glory nothing is wanting; but he is wanting for ours." The Academy elected him in the following year.

HERMANN LUDWIG FERDINAND HELMHOLTZ was born August 31, 1821, in Potsdam, the Prussian Versailles, the town of palaces, which gave birth to Alexander von Humboldt, and holds the ashes of Frederick the Great. His father was a teacher at the gymnasium in Potsdam, and a man possessed of a great store of knowledge. Under his guidance Hermann was soon prepared to enter the institution, where, as usual, too much Latin and Greek was taught for his youthful taste. He was, however, not permitted to shirk any of his studies, and, with that patient perseverance which is a dominant trait in his character, he ran through the whole curriculum of the gymnasium before he had reached his seventeenth year. He then went to Berlin, and entered the military school of medicine known as the Frederick William Institute, or as the *Pépinière*. It is true that, if medicine was the study of his choice, there were ample facilities for it at any German university. But there were reasons which rendered it advisable to send him to a military institution. Prussia demands of all her sons several years of active service in the army, to begin when they are twenty-one years of age. This regulation provides her with large available forces, but sadly interferes with the pursuits of the young men at a time when the foundation must be laid for their future career. To overcome this difficulty, and to create at the same time a comparatively cultured army, it is provided that those who attend for a short period some military institution, and pass a satisfactory examination of a certain literary grade, shall be more or less exempt from active service in time of peace. Young Helmholtz's parents considered it best that he should avail himself of this provision at an early age, in order to insure for him an uninterrupted season of study in subsequent years. But Hermann had also his own reason for entering the military school of medicine. He had been seized with that martial fever which is apt to attack the youth of countries where there is continually a gaudy display of soldiers.

He went to Berlin, and on the three years which he spent there Helmholtz still looks back as the most pleasant of his life. There were strict rules to be obeyed, and there was hard study to be done; but there were also short furloughs to be obtained for rambles through the city, and some even long enough for a journey to the old home at Potsdam. The constant feeling of being on duty developed in him that noble manliness which so deeply marks every feature of his face.

When he was twenty, he graduated from the Pépinière with an article prepared for his examination marked with all the learning that he has since made his own. His dissertation was on the subject of the nervous system of invertebrate animals, and is the only morphological investigation which he has ever made.

His treatise evinced such uncommon ability that he was at once ordered to attend as assistant surgeon the hospital of the *Charité*, in Berlin, and after a few months he was promoted to the rank of physician in a regiment of hussars, stationed at Potsdam. This was wise, as it placed the youth again under the wholesome restraints and the kindly influences of the family circle, instead of allowing his hard-earned knowledge and well-trained *physique* to run to waste, like those of most young officers.

Helmholtz published in the same year the first fruit of his independent researches. It was an article on the nature of fermentation, which contains several remarkable suggestions on the subject of spontaneous generation. The excellence of this production opened to him the pages of the prominent medical magazines, and gave him the honor of an engagement as contributor to the "Berlin Encyclopædic Lexicon of Medical Sciences." The most important among the numerous articles which he wrote during this period is one on the chemical analysis of the consumption of matter by muscular action; another on animal heat, especially in relation to the question whether the body of an animal throws out the same amount of heat which is produced by the combustion and transformation of its food; and a third, which treats of the development of heat through muscular action.

The great variety of subjects treated in his short publications during these years excludes the hypothesis that there was in his studies a gradual growth toward the discoveries which uphold his worldwide fame, and for which every branch of study related to the physical sciences is so greatly indebted to him. There are, however, impressions which every reader of these papers receives. Helmholtz is nobody's pupil; he stands on the basis of personal observation, and speaks whatever he believes to be true. To show how independently his mind was developed, it may be stated that he could not be induced to attend a single lecture on physical science while a student in Berlin.

In 1847, being consequently only twenty-six years of age, he published his important work, "The Conservation of Force." The discovery of this principle of Nature has been of the greatest moment to the progress of the whole range of physical sciences. This law is, in fact, indispensable to a sound understanding of any and every phenomenon in the animate and inanimate world. And Helmholtz opened his scientific career with a production that would have worthily closed a long life of study and fame.

After the publication of "The Conservation of Force," he was appointed prosector at the Anatomical Institute in Berlin, where he remained about a year. In 1849 he was called to the chair of Physiology at the University of Königsberg. He accepted it, and filled it for a period of nearly six years, in which he made some brilliant discoveries and inventions, which have proved a blessing to thousands of sufferers.

It had been generally held that the time needed for conceiving a thought, and experiencing sensations, could not be measured. Prof. Helmholtz (1850–'51) invented, however, a series of highly-ingenious processes for measuring the duration of any action, however swift, and demonstrated, in a number of papers, that there is a lapse of time before a sensation caused on one end of a nerve is felt at the other. He proved, for example, that, when we touch a thing, it takes a little time before we know that we touched it, and that, however rapid and seemingly instantaneous our actions be, some small period of time must elapse before we can begin to execute the mandates of our will. In 1851 he invented a mirror with which to examine the retina of the eye in living beings, and in the following year he described an ophthalmometer, or an instrument for measuring the eye, which has proved of much service. His next researches were on the field of spectro-analysis, and he demonstrated that the results obtained by painters in mixing colors do not correspond with those of mingling the pure spectral colors of solar light or of other lights decomposed with a prism. He showed, for example, that, when yellow and blue rays of light are combined, the color produced is white, and not green. In connection with this subject, he entered into an admirable analysis of the extent and limits of human observation, and totally refuted at the same time Sir David Brewster's alleged decomposition of solar light.

In 1855 Helmholtz was called to the University of Bonn as Professor of Anatomy and Physiology, and director of the Anatomical and Physiological Institute. Three years later he removed to the University of Heidelberg, to fill a chair of Physiology, which he continued to occupy for more than twelve years. It would be tedious to enumerate every thing that his patient labor and the unerring logic of his mind demolished, while there, in the snug but shaky edifices of conservative science. He scattered the results of his researches with a liberal hand all over Germany. Every scientific periodical was honored by him with a contribution on its own specialty. There is, however, one class of his articles that appeared during this period which must not be overlooked. He had rendered valuable services toward an exact understanding of the mechanism of the eye, and had observed the physical laws of vision. He now turned his attention to a subject of equal importance. He investigated the mechanism of the ear, and searched for the laws of sound. His discoveries are laid down in his "Doctrine of the Sensations of Sound, as a Physiological Basis for the Theory of Music." It contains a complete analysis of the conditions of harmony, and reduces its æsthetic principles to a few fundamental physical laws.

Helmholtz's new doctrines of sight and sound have been universally received, and his fame will last as long as they continue to be among the main pillars of physical science. His name is also inseparably connected with the doctrine of the conservation of force, which subsequent investigation at the hands of others has shown to be the key-note of every law of Nature. Its bearing on the doctrine of evolution is, however, so strong and favorable that, like that doctrine, it will need much time before it receives an unreserved acceptance. Helmholtz tested, a few years ago, the progress which the doctrine of evolution has made, by asking the congress of natural philosophers, assembled at Speier, to declare, openly, who of them were in favor of, and who against, Darwinism. The roll was called, and there was not one against it. Helmholtz removed, in 1871, to Berlin, and holds there a professorship in the University.

CORRESPONDENCE.

INSURANCE VALUE.

To the Editor of the Popular Science Monthly:

IT is one of the most difficult things to popularize mathematical science, either abstract or applied. On this account, and not for want of good intention, I have failed, in my "Politics and Mysteries of Life Insurance," to make myself understood on some points, even by my able and candid reviewer in THE POPULAR SCIENCE MONTHLY for May. The reviewer says: "If the holder of a 'single-premium policy,' having twenty or more years to run, becomes desirous to surrender his policy at the end of five years, he should get back from the company, not only the 'reserve,' but also that portion of the 'insurance value' that has been set apart by the company to compensate for the risk attached to the remaining fifteen or more years of the policy's term."

This, I regret to be obliged to say, is not quite correct. But I must confess it is not an altogether unnatural inference from the definition of "insurance value" given on page 12 of "Politics and Mysteries." "Insurance value" is there spoken of *as if* it were a sum "paid in advance." It is really only a *function* of the sum so paid, not a part of it. The "single premium," apart from the margin added to defray office expenses, that is, the *net* single premium, is itself the reserve. The cost of the first year's insurance, so far as it is done by the company, comes from the *interest* of that premium. It is the present value of so much of the interest as is not needed to make up the "self-insurance" or reserve at the end of the year. And this reserve is the net single premium at the party's present age. And just so comes the cost of the next year's insurance, so far as it is done by the company. The "insurance value" of the policy at the start is the present value of all these costs, or partial interests, discounted both by the interest and mortality rates. Consequently it is nothing to be returned in addition to the reserve. On the contrary, if the life is a good one, which may be expected to live long enough to pay more than the average toward death-claims, something must be deducted from the reserve, which will bear some proportion to the "insurance value" of the policy at the time of surrender, to compensate the company for the loss of the *future wherewith* to make up the deficiencies of lives that are not good. This is on the principle that, other things being equal, the profitableness of policies will be as their "insurance values."

If we speak of "insurance value" as being actually contained in the single premium (net), then the balance thereof is less than the "self-insurance" or reserve. We have no technical name for that balance. Prof. Bartlett calls it (*see* "Politics and Mysteries," page 73), the fund which "works at compound interest till it amounts to the sum assured." But it is more, as will appear presently.

The two new technical terms "self-insurance" and "insurance value," which I have felt obliged to introduce into the discussion of this subject, cannot be well understood without noting their relation to each other.

Self-insurance is the amount in the hands of the company at the end of a policy year, which the insured party has paid beyond the normal cost of the past insurance. In the fact of paying so much beyond the normal or assumed cost, he insured himself to that amount. And the law has stepped in and made it emphatically a self-insurance, by virtually forbidding the company ever to apply it to the payment of a claim on any other policy.

Insurance value—and I should have done better by so defining it—is the present value, discounting by the assumed rates both of interest and mortality, of which the policy *may be expected* to contribute toward the payment of death-claims, including its own, so far as that, when it occurs, shall not be self-insured.

This "insurance value" has of course nothing to do with the margin arbitrarily added to the net premium to defray working expenses, etc., nor with the excess of interest that may be realized on investments over the assumed rate. It would be a very extraordinary emergency indeed in any well-established company that would call these into requisition for the payment of death-claims, and, when not required for expenses, they are returned annually as surplus in mutual companies. It is strenuously argued that, because they *may*, if necessary, be used for the payment of claims, they should, along with insurance-value as above defined, be taken into account in fixing the maximum "surrender charge." But, as their discounted values, reduced by the improbability of their requisition for company use, would not materially differ in proportion from the insurance values, the argument for taking them into account is a good deal more nice than wise.

As the surrender value which can be fairly and wisely stipulated to be paid, if not paid when not stipulated, is a matter of great practical importance, let me explain particularly the case put by my reviewer of a single premium endowment insurance for twenty years, to be surrendered at the end of five years. If entered at forty, by the actuary's table, at four per cent., its net single premium would be $511.15 for $1,000. At the age of forty, the natural net premium to insure $1,000 for one year is $9.96. This, at four per cent., will amount at the end of the year to $10.36, so that the company, exclusive of the party himself, by insuring $1,000, runs the risk of losing $989.64 if he dies, and of gaining $10.36, if he does not. There is in this case no reserve at the end of the year, and no occasion to use the term "self-insurance." But if $511.15, which at the end of the year will amount to $531.60, it runs the risk of losing only $468.40. And, if in the former case the company may properly be said to have insured $1,000, in this it insures only $\frac{468.40}{989.64}$ \$1,000=\$473.31. For this insurance the party paid in advance (by part of his interest discounted) at the same rate as for the $1,000 in the other case, that is $\frac{473.31}{1,000}$ \$9.96=\$4.72 nearly. But if he had died during the year, his heirs would have received $1,000, the same as in the other case. Therefore, since the company insured only $473.31, the party himself must have insured the remaining $526.69; and this is precisely the reserve which, in Massachusetts, the law requires the company to show on hand at the end of the year, if the party is then alive, as the sum necessary under the assumptions to enable it to carry through the remaining nineteen years of the contract. Hence, the whole of the *insurance* operation of the first year, under this contract, is, that the company, exclusive of the party himself, will lose $473.31 if he dies, and gain $4.90 if he does not. The amount of the $511.15, after deducting the $4.90, which belongs to the company in case of survival, to pay other death-claims with, is a mere deposit held in trust, subject to the terms of the contract and the provisions of law.

If, having paid $4.72, the normal cost of the first year's insurance, we find those of all the succeeding years and discount them back to the start by both the assumed interest and mortality, their sum will be what I call the "insurance value" of the policy at its inception—"the sum which, paid in advance, under the assumptions, would exactly pay for all the insurance which the company is to do under the policy, as distinguished from what the party is to do himself."

Now, if we conceive that this sum, which in this case is $50.42, is a part of the $511.15, the balance, $460.73, is less than what will make the self-insurance or reserve required at the end of the year, and it is more than a sum which "works at compound interest till it amounts to the sum assured" at the end of the term. That would be only $456.39. The truth is, that the $50.42 is not a part of the sum in hand, but one of its functions. The complementary function, exhausting the power of the sum, is the $460.73—the "insurance value" of the self-insurance, so to speak, including in the self-insurance the endowment. The endowment, as will easily be perceived, becomes self-insurance, by assuming, what is the same to the company, that the party, if he lives to enter it, will be *sure to die* in the last year of the term.

If there were any practical utility in it, we might analyze the premium into three functions: the insurance value of the insurance by the company, the insurance value of the self-insured, and the endowment-value function, making, in the present case, $511.15=$50.42+$135.97+$324.76.

At the end of five years, in the case of this policy, the reserve or self-insurance is $595.82, and the "insurance value" is reduced to $37.90. According to the absurd rule, imported from England, no regard is had to "insurance value" withdrawn, but only to reserve, and the "surrender charge" is from one-third to two-thirds of the latter. Of course, no one would think of sacrificing a "paid-up" policy at such a rate. Prof. Bartlett recommends that in this case the company should deduct the entire "insurance value" and pay $557.92 as the "surrender value." My own opinion is, that eight per cent. of the "insurance value," or $4.03, is a sufficient charge to keep the company whole. This charge of eight per cent. is based on two assumptions, either of which seems to me reasonable: First, that the members who will select themselves out of a mutual company will not be collectively as much as eight per cent. better than the average. Secondly, that eight per cent. of the "insurance value" deducted from the reserve will be more than sufficient to replace that withdrawn with others as good.

Elizur Wright.

Boston, *April* 22, 1874.

EDITOR'S TABLE.

THE CENTENNIAL CELEBRATION.

HOW shall this nation behave itself when it comes to be a hundred years old? Something extraordinary must be done to signalize that event. For we are a great people, spread over a great continent, on which are great lakes and rivers, and prairies, and coal-fields, and copper-mines; and we have had a great war, and got a great debt and a great common-school system, and how shall we *pose* in a manner befitting all this greatness when the nation has come to be as old as a very old man? To be sure, a large proportion of this greatness affords no very obvious ground of self-exaltation. The vast continent, with its mighty resources, we certainly did not make, and have got possession of it by means that are not greatly creditable, while neither a great civil war nor a great debt growing out of it is a thing to be much boasted of in this age of the world. Nevertheless, our people do not care to discriminate very nicely in this way; they have got a "big thing" in hand, and manifestly a great destiny before them; and by much contemplation of these things they have engendered a self-consciousness of greatness, which it is calculated will reach the exploding point by the Fourth of July, 1876. What manner of demonstration will befit that occasion is now the perplexing question.

The special event to be commemorated is undoubtedly political. The act of severance by which we established our national independence was a political transaction. We refused any longer to accept a foreign rule, and decided to shape our own government and do our own governing. We worked out a measure of political reform by laying down the simple principle that the people living here are better judges of what they want than people on the other side of the world. It was a step of rational advance in the management of public affairs, and was significant not so much for any vast or absolute good immediately attained, as for opening the way for other and better things in the future. We abandoned monarchy and a state Church, toggled up an arrangement called the Constitution, and entered upon the experiment of shaping civil institutions in accordance with reason. After a hundred years of trial, we find ourselves called upon to make report of the net results of our experiment. What and how much have we done to make humanity our debtors? How have we used our opportunities? How much has been gained toward the progress and welfare of man by our experience? The Centennial Celebration should be the suitable occasion to return answers to these questions.

Obviously it will not do merely to carry out John Adams's old programme of bell-ringing, powder-wasting, and hosannas to liberty, by raising the Fourth of July, 1876, to the tenth power of uproar and rhetorical bombast. And, although the event to be commemorated is political, nothing could be more absurd than to go into a paroxysm of political jubilation. If politics alone is to be taken into account, there will be precious little to celebrate, for it is matter of world-wide notoriety that the course of the nation has been downward in this respect from the start. British rule had given us better men in 1776 than a century of republican experience can turn out in 1876. In purity, honor, self-sacrifice, and the triumph of patriotic principle over selfish ambition, the politicians of to-day will bear no comparison with those who founded the government a hundred years ago. If we are to be judged solely by the political fruits of our political system, it would be most appropriate to devote the Centennial to fasting and humiliation, with the accompaniments of sackcloth and ashes.

But, if technical politics has degenerated and fallen in esteem, there has been a noble progress in other directions and in other things, involving the thought and life of the people, which may well be commemorated on our centennial birth-year.

The act of severance which made us an independent people, as we have said, was a measure of government reform in the direction of less government, or a restriction of its powers and offices. There was an increase of self-government at the expense of state control, under the theory put forth by the author of the Declaration of Independence, that "the world is governed too much." By declaring at the outset, that the source of power is not in the divine right of hereditary rulers, but among the people themselves; that religion is not a fit matter for the state to deal with, but must be left to individuals; and by organizing a political system, in which the management of their own interest was thrown back upon the people by local and municipal regulations, while the powers of the General Government were strictly limited and defined by a written constitution, a new order of things was theoretically assumed and partially adopted, which, if carried out, could not fail greatly to narrow the sphere of legislation and reduce the pretensions of politics. The preamble to the Constitution, which declares the reasons why our government was established and the principles which should animate and pervade all our legislation and administration, though couched in general terms, if fairly construed and thoroughly executed, would work the most profound and beneficent reform that could be conceived in the conduct of civil affairs. It would strike away half the machinery of political regulation, and raise the other half to a double efficiency and power. The founders of our government declared that it was ordained to "establish justice," and if the state were confined to that great duty, and the whole moral power of the community were concentrated upon the attainment of that result, the thousand other things with which government now meddles might safely be let alone. The practical working of our political system, it must be confessed, has fatally contravened the intentions of its founders; and, in the attempt to attain a multitude of illegitimate ends, justice, instead of being established, is sacrificed. Nevertheless, by all the implications of the theory upon which we started, politics was to be increasingly circumscribed, and the community left more and more to self-regulation, self-development, and the course of private enterprise. And, happily, political meddling and interference have not been able to defeat this powerful tendency of things. There has been a progress of intelligence, a liberalization of ideas, a promotion of welfare and an improvement of the social condition, which are to be credited, not to politics, but to the laws of human nature and the spontaneous agencies of social life. It is our accomplishment in these directions that we think may be most fitly marked and commemorated in the approaching Centennial.

One of the grandest achievements of the past century is the victory that has been gained over the old spirit of national narrowness and jealousy by which all foreigners were regarded as enemies. Increased inter-communication through the extraordinary modern facilities of travel, and a more familiar acquaintance with the internal life of other countries, have dissipated much of the hostile feeling which was formerly fostered as one of the first duties of patriotism. Commerce has aided to break down international prejudices, and the interchanges of thought and a common interest in the discoveries of science and the inventions of art, by which human condition is ameliorated, are still further favorable to the sentiment of unity among the family of civilized nations. International bigotry is of course very far from being extirpated, and is still available to the demagogue, but it has been greatly diminished. Man is certainly becoming more by virtue of his manhood, and less by virtue of his nationality. It may safely be affirmed that, if the feelings of different peoples could be consulted, and if it were not for the machinations of politicians, international wars would in future be impossible. It may be long before this feeling of sympathetic regard and the duty of justice toward strangers will become sufficiently strong to rule the policy of governments; but that it is increasing in influence is a pronounced and hopeful tendency of modern times, and it should be recognized and strengthened in all possible ways and on all practicable occasions. For these reasons it seems in the highest degree proper that the celebration of our hundredth anniversary should have an international character. To shut ourselves up in surly exclusiveness on our centennial birth-year, and endeavor to revive the illiberal moods and disagreeable memories of a century ago, would be to violate the spirit of the occasion, and, as the phrase is, to "go back" on the best work of humanity for the last hundred years.

Another great result of civilization during the past century, and in which this country has had a conspicuous share, is the development of the arts, the multiplication of inventions, the progress of industry, the extension of science, and that conquest of material Nature which gives new advantages to all ranks of society. In this race of constructive and pacific improvement we are the competitors of other nations, while each type of people makes contributions in accordance with its own genius and circumstances. In the multiplicity and ingenuity of our devices, and in their adaptation to the practical wants of mankind, this country need not be ashamed of its position. It has been long perceived that great mutual advantage would result to different nations, and an immense total gain to civilization, by bringing into close comparison the best that each community has to offer in the way of artistic and industrial productions. England, France, and Austria, have instituted international exhibitions, and invited the coöperation of the world to make them in the highest degree instructive. Why should the United States not join in this generous rivalry, and make an International Exposition the chief feature of its Centennial Celebration? A project of this kind has been ably devised and thoroughly matured; it is to be hoped that a people so full of great things will not break down in its execution under such memorable circumstances, and especially after the enterprise has gone so far as to implicate the national honor.

A CHEMICAL CENTENNIAL.

And, as centennials are now in order, we are happy to see that there is beginning to be a stir in behalf of a Scientific Centennial Celebration for the present year. Dr. H. Carrington Bolton, of the School of Mines in Columbia College, has written a letter to the *American Chemist*, stating that the year 1774 was so memorable for the number and importance of its chemical discoveries, that it may with good reason be regarded as the birth-year of the science. It was in that year, he states, that the Swedish chemist Scheele first isolated chlorine and threw important light upon baryta and manganese. Lavoisier's experiments upon tin, which led to subsequent discoveries of immense importance, were made also in that year. Dr. Bolton says: "Wiegleb proved alkalies to be true, natural constituents of plants. Cadet described an improved method of preparing sulphuric ether. Bergman showed the presence of carbonic acid in lead white. On the 27th of September in this year Comus reduced the 'calces' of the six metals, by means of the electric spark, before an astonished and delighted audience of *savants*. On the 1st of August, 1774, Priestley discovered oxygen, the immediate results of which were the overthrow of the time-honored phlogistic theory and the foundation of chemistry on its present basis. It surely requires no lengthy argument to prove that the year 1774 may well be considered as the starting-point of modern chemistry."

In commemoration of these discoveries, Dr. Bolton suggests that "some public recognition of this fact should be made this coming summer. Would it not be an agreeable event if American chemists should meet on the 1st day of August, 1874, at some pleasant watering-place, to discuss chemical questions, especially the wonderfully rapid progress of chemical science in the past hundred years?"

We think this suggestion excellent, and hope it will be carried out. Fortunately the date is favorable, as it occurs in the season of general vacation. We suggested some time ago that such a centennial as this ought to be celebrated; and, as the great discoverer of oxygen was exiled to this country by foreign intolerance, and died here, we proposed to erect a statue to him in the Central Park. But monuments to scientific men are not yet much in favor. They erected one to Dr. Jenner, the discoverer of vaccination, in Trafalgar Square, London; but the place was wanted for a military hero, and so the Jenner statue was carted away to an obscure place in Kensington, and planted down by the public water-filters. He, whose discovery had saved more lives annually than the collective armies of Europe could destroy, if all put at their business, had to give place to one who had signalized himself in a small way, in the work of destroying his kind. Let the chemists meet and celebrate the birth and growth of their science; perhaps in another hundred years the turn of the discoverers will come.

"RESPONSIBILITY IN MENTAL DISEASE."

Whatever may be said about the futility of "theories" and the importance of "facts," it is certain that we can no more escape the use of the former than the recognition of the latter. Facts are nothing until they are brought together, compared, interpreted, and some view of them arrived at—and that is a theory. From the most trivial events in daily life to the grave and critical decisions of deliberative bodies, from the question of taking along an umbrella to that of the financial policy of the nation, or a declaration of war, action follows theory as the all-essential thing in the determination of results.

A tragedy has just been enacted in Boston, which affords an impressive illustration both of the importance of theories and the terrible evils that flow from the adoption of wrong theories. A year and a half ago a lad named Jesse Pomeroy was convicted of the atrocious crime of luring young children into by-places and gashing and mutilating them in the most cruel manner. He carried on this savage practice for months, operating upon no less than seven children, and was then taken up by the authorities. How to estimate his conduct, and what to do with him, was then the question. The nature of the acts that he had perpetrated, by their wanton and persistent cruelty, marked him out as not only an exception to the class of youthful offenders, but as an inhuman monster, wanting in moral sense and destitute of the common attributes of humanity. His conduct showed that he was abnormally and insanely constituted. That he was a deficient human being was just as evident as a matter of fact as if he had been born blind, deaf, or without arms. But the authorities proceeded upon another theory—they assumed that he was like other bad boys, and could be reformed, and so they sent him to the State Reform School. After remaining there a year and five months he was released "on probation"—five years before the time at which he would have been entitled to a legal discharge.

On the 22d instant "the body of a boy, four years of age, was found by the water-side in South Boston, bleeding from a multitude of wounds. There were eighteen stabs in the region of the heart. The hands were cut, as if in the little fellow's attempt to ward off the blows of the murderer. The throat was slit, and one eye was nearly cut from its socket. Footmarks in the mud seemed to prove that the child had been led to the spot by some older companion, who must have lifted him down from the wharf, where the prints first appeared; and the condition of the body showed that the murder had been committed but a very little while before its discovery—that is to say, in broad day." Jesse Pomeroy was suspected of the deed, arrested, and confessed that he perpetrated it.

This case, shocking as it is, is by no means rare in its quality. The instances are numerous of individuals who have displayed a propensity for the apparently wanton-infliction of pain and destruction of life. The life-destroying impulse may take the direction of suicide, or be turned against others, and frequently manifests itself as an ungovernable propensity to kill infants and young children; and examples are not wanting in which persons are conscious of this terrible tendency in themselves, and, while still able to resist it, invoke restraint from others as their only protection. There is such a thing as insanity—a diseased condition of mind in which reason and self-control are destroyed and responsibility ceases. There cannot be a doubt that Jesse Pomeroy belongs to this class, and his first perpetrations of cruelty should have been held to establish this as absolutely as if his intellect had been shattered and he had been a raving maniac. If the theory at first acted upon, that he was soundly constituted, responsible, and capable of reform, be carried out, of course nothing remains but to strangle him in due form—and that is the short method which society generally prefers, and which, while it appeases public indignation, disposes of the case, and is supposed to end all difficulty. But it is beginning to be seen that these summary procedures do not put things to rest. With every new instance of this kind we are again confronted with the perplexing problem of how far the defective-minded and badly-constituted are amenable to penalties that are prescribed to the mass of the community who are recognized as sane and responsible.

As we have said, insanity is a fact of human nature—troublesome to define, difficult to limit, and often hard to establish, but which must be met and dealt with as a stern reality. Obscure in its manifestations, profound and remote in its causes as it often is, we are liable to encounter it at any time, while it is so serious a thing that prompt and decisive public action is compelled to be taken upon it. Its questions arise continually in our courts, and have to be passed upon by juries of citizens, upon whose theories of the subject depend the issues of life and death. And besides these intrinsic difficulties in arriving at correct judgments regarding alleged cases of insanity, there are extrinsic difficulties more formidable still, for no subject is more overlaid with public prejudice than this. While such things as law, justice, civilization, and Christianity, have asserted their supremacy for thousands of years, it is only within recent times—so recent as to be still within the memory of men—that the system of atrocious barbarity by which the insane had been always and everywhere treated has been brought to a termination. But, while humaner feeling and increasing enlightenment have gained the victory, it would be idle to deny that much of the ignorance, prejudice, and superstition, which gave rise to the old order of things still continues. There still survive the instinctive distrust, antipathy, and repugnance, toward the victims of mental disorder, as though their calamity were a disgrace and reproach to the nature of humanity. With such lingering errors in the popular mind, combined with a lack of the information which science has furnished, it is not surprising that we should often witness outbreaks of public passion so vehement as to affect the administration of justice. The case of James Freeman is still fresh in the memory of this generation. He had murdered a whole family under circumstances of atrocity that ought at once to have raised the suspicion that he was not a sane man; and, when brought to trial in Syracuse, his appearance attested him to be a half-demented brute. That the State was saved from the disgrace of executing him as a responsible criminal was due not to the intelligence or humanity of the people of Central New York, but to the noble intrepidity of an eminent lawyer, who, with no hope of reward, faced a storm of public indignation by voluntarily undertaking his defense. The evidence of public prejudice in relation to this subjust is still further seen in the general impatience that is evinced when the plea of insanity is urged in capital trials. No doubt this plea has come to be a resource of lawyers, and is made the most of without regard to justice, in the defense of criminals; but the license of lawyers is a settled policy in the procedure of courts, and it is to be expected that they will strain and abuse every plea that can be made available. Moreover, as we have repeatedly said, insanity is a fact, and from its nature a cause of crimes the most inhuman; and while, in cases of suicide, mental derangement is alleged by coroners' juries as almost a stereotyped cause, it is not only proper but imperative to inquire if it may not also be a cause in cases of homicide. This plea is not to be ruled out or escaped as illegitimate; and the only rational course is to prepare to meet it and deal with it intelligently.

Technically, this subject belongs to physicians, as it is to their profession that we are indebted for our knowledge of it; and they are also the parties to whose intelligence and experience society must appeal in all obscure and doubtful cases. But the subject belongs, also, to the general public, in a far more important sense, for citizens not only have to share in legal proceedings in which insanity is involved, but they have to deal with it in its early stages and its private management. Nor is this all. As the past study of mental derangements, from the scientific point of view assumed by the medical man, has contributed largely to the extension of our knowledge of human nature, so there is no better method now of getting at that knowledge than by considering the aberrant and disordered manifestations of the human mind. It is quickly found that mankind are not to be sharply divided into two groups, the sane and the insane—the responsible and the irresponsible—but that these states pass into each other by degrees, so that men are to be judged, as it were, by their position upon a scale of organization, character, and opportunities. Dr. Henry Maudsley, a philosophic student of this subject, and a distinguished authority in the alienist branch of medical practice, has just prepared a valuable popular work[1] upon this question, which contains just the information that needs to be widely disseminated. The book is a compact presentation of those facts and principles which require to be taken into account in estimating human responsibility — not legal responsibility merely, but responsibility for conduct in the family, the school, and all phases of social relation in which obligation enters as an element. The work is new in plan and was written to supply a widely-felt want which has not hitherto been met. It may be strongly recommended to general readers, and, as the important truths it contains are not enforced in the prevailing system of education, it should be especially read by young men as a preparation for the duties and responsibilities of citizenship.

[1] "Responsibility in Mental Disease," by Henry Maudsley, M. D. (No. 9 of the "International Scientific Series"). 313 pages. Price, $1.50. D. Appleton & Co.

If any suppose that the questions considered in the previous article are not practical and pressing, we offer them an additional fact. Since it was in type, the State of New York has undoubtedly hanged an irresponsible maniac. Joseph Waltz was executed at Catskill, May 1st, for a murder so wanton and causeless as to raise a strong presumption of mental derangement, which was also confirmed by other circumstances. His keeper in the jail proceeded upon the same theory as that of the Boston authorities in the case of Pomeroy, and assumed that he was sane. He had been frequently cautioned against exposing himself to the murderer, but always answered, "Joe won't hurt me;" yet the day before his execution he broke his keeper's skull with an iron bar. The existence of homicidal mania is a well-recognized fact, and there was the strongest presumption that this was an instance of it. But, although the second attempt to kill tended to confirm the evidence of the first—that Waltz was of unsound mind—the Catskill people, it is said, turned out by thousands with the view of breaking jail and lynching him, so that the military had to be called on to prevent the crime of public murder. The only party who could have legally interfered to stay the execution until a more thorough inquest into the case might be had, was the Governor at Albany, elected by the help of the aforesaid mob, and, of course, "accountable to the people," and he did not choose to interfere.

Waltz's brain was examined by the physicians after his death, and reported free from disease. It was unusually large, weighing fifty-four ounces, which is five ounces above the average. "The membranes and gray matter were found in a healthy state, and the convolutions were perfect. An incision disclosed no softening, and a critical examination failed to discover any organic malformation or disease." And it was therefore the opinion of the examiners that there was nothing in the organ to indicate insanity. Of this it may be said: 1. That a hurried examination, under such circumstances, of so delicate and complex an organ, and where the indications of morbidity are often most obscure, is not in the highest degree trustworthy; 2. That insanity may exist where dissection cannot detect the evidence of it in the cerebral tissues, as where it is due to a morbid condition of the blood; 3. If profound disease *had* been discovered in the organ, it would not have been held to prove insanity, and we should have been reminded of those cases in which extensive brain-disease has coexisted with entire sanity. We should have been further assured that the proof of insanity is not in the disclosures of the scalpel, but in the manifestations of conduct. The state of public feeling and intelligence is well indicated by the tone of some of the newspapers, which insist that maniacal murderers may just as well be hanged and got out of the way as other murderers. One of them says: "Had Waltz been a resident of this city he would not have been hanged, probably, but would have escaped on the plea of insanity. Fortunately, however, he is hanged and well out of the way; and we doubt not that society, in the light of such facts as his crime presents, will eventually come to the view that it must hang all murderers, sane or insane." In such a case, as another morning paper remarks, "if the maniac is hanged, it is highly desirable that he should be hanged as a maniac, so that the community and the asylums may know how they stand in relation to each other." An excellent suggestion, which might be carried out by doing this branch of the business in the State asylums for the benefit of the lunatics.

There has been much inquiry in this country for a good portrait of Herbert Spencer, and preparations have been, for some time, in progress to furnish it. Mr. Spencer was requested to sit for an oil-painting, and to select his artist for the work. He chose Mr. W. H. Burgess, of London, one of the greatest masters of expression in our time, and the work produced is regarded by Mr. Spencer, and by those who know him, as a remarkable success in portraiture. The portrait, which is now on exhibition at the Academy, has been, for several months, in the hands of H. B. Hall, jr., for the production of a large steel engraving suitable for framing. The print is an excellent likeness and an elegant work of art, and it will be the picture by which Mr. Spencer will be known to the future. A limited number of artist's proofs have been taken on fine India paper, price ten dollars, and those who wish to possess themselves of one of these impressions may do so by applying to the editor of The Popular Science Monthly.

LITERARY NOTICES.

The Land of the White Elephant. Sights and Scenes in Southern Asia. A Personal Narrative of Travel and Adventure in Farther India, embracing the Countries of Burma, Siam, Cambodia, and Cochin-China (1871, '72). By Frank Vincent, Jr. 316 pp. Price, $3.50. Harper & Brothers, New York.

The perversity by which language becomes turned to the conveyance of false ideas seems to be as universal as it is inveterate: near home, the June magazines are published in May, and journals are issued once a quarter, while in Farther India the white elephant is as "black as a coal," and of half a dozen other colors. Human nature secretes the same incongruities wherever we find it. Frank Vincent has written, and the Harpers have published, a beautifully illustrated and most readable book about the people, the products, the cities, and the temples, of a vast tract of Indian country, known as the "Land of the White Elephant." In the course of his three years' journey round the world, the author of this volume spent eleven months in the "marvelously-beautiful countries," and amid the "strange people and stranger customs" of Farther India—a country of one million square miles and twenty-five million inhabitants, with a productive soil and extended commerce. After visiting every thing of interest in Lower Burma, the writer made an excursion up the great Irrawaddy River to Mandalay, in Upper Burma, or Ava—a distance of seven hundred miles. Mandalay, the capital, is a new city. It began to be built in 1855, and in 1857 the king and court adopted it as the royal residence, while it now has a population of one million. Let Chicago hide its diminished head in presence of the enterprise of these heathen. "The city proper is a square—a mile on each side—and is surrounded by a lofty and very thick wall of loose brick (unplastered) with a notched parapet, and having a broad and deep moat filled with clear water. There are three gates on each side, and macadamized streets about a hundred feet in width, leading from them, intersect the city at right angles; then, between these are small and irregular streets and by-paths. Along the sides of the larger avenues there run channels for carrying water (which is brought from the river in a canal fifteen miles long) throughout the city. Each gate-way is surmounted by a lofty, pyramidal-shaped wooden tower with the customary terraced roof, and, at irregular intervals, there are turrets, raised a little higher than the wall, and surmounted by small wooden pavilions of the same model as those over the great gates. We crossed the moat on a massive wooden bridge, and passed through one of the western gate-ways—the only one through which corpses are allowed to be taken from the city, as my guide observed. The gates are of enormous height and thickness, and are built of teak beams, fastened together with huge iron bolts." The author says, "I determined to make this trip, to pay my respects to his majesty the king." Accordingly, on his arrival in the city, through the favor of a Chinese resident who enjoyed the friendship of his majesty, he was granted an audience. The king seems to have taken a fancy to him, and offered him good business facilities and as many Burmese wives as he wanted, if he would stay and help him; but the virtuous young man said he would see his folks about it before deciding.

Inspired by his elephant-hunting curiosity, Mr. Vincent afterward visited the King of Siam at Bangkok, and discourses upon the condition of his elephants and the philosophy of the subject as follows:

"The first animal whose stable we entered was quite small, and possessed few of the peculiar characteristics of a 'dark-cream albino,' excepting perhaps the eyes. The keeper fed him with bananas, and caused him to make a *salaam* (a profound salutation or bow) by raising his proboscis to his forehead for a moment and then gracefully lowering it to the ground. In another shed we saw a larger and also whiter elephant, its body having the peculiar flesh-colored appearance termed 'white.' Here there was, besides, a white monkey—'white animals are the favorite abodes of transmigrating souls'—kept to ward off bad spirits, as the attendant informed us.

"Sir John Bowring—and he is about the only person who has written at length on this subject—in a very interesting 'chapter on elephants,' tells us that the Buddhists have a special reverence for white quadrupeds; that he has himself seen a white monkey honored with special attention. Also, that white elephants have been the cause of many a war, and their possession more an object of envy than the conquest of territory or the transitory glories of the battle-field. In the money-market the white elephant is almost beyond price. Ten thousand sovereigns (fifty thousand dollars) would hardly represent its pecuniary value; a hair from its tail is worth a Jew's ransom. 'It was my good fortune,' he says, 'to present (in 1855) to the first king of Siam (the Siamese have two kings exercising supreme authority) presents with which I had been charged by my royal mistress. I received many presents in return; but the monarch placed in my hand a golden box, locked with a golden key, and he informed me the box contained a gift far more valuable than all the rest, and that was a few hairs of the white elephant. And, perhaps, it may be well to state why the elephant is so specially reverenced.

"Because it is believed that Buddha, the divine emanation from the Deity, must necessarily, in his multitudinous metamorphoses or transmissions through all existences, and through millions of æons, delight to abide for some time in that grand incarnation of purity which is represented by the white elephant. While the *bonzes* teach that there is no spot in the heavens above, or the earth below, or the waters under the earth, which is not visited in the peregrinations of the divinity—whose every stage or step is toward purification—they hold that his tarrying may be longer in the white elephant than in any other abode, and that in the possession of the sacred creature they may possess the presence of Buddha himself. It is known that the Cingalese have been kept in subjection by the belief that their rulers have a tooth of Buddha in the temple of Kandy, and that on various tracts of the East impressions of the foot of Buddha are reverenced, and are the objects of weary pilgrimages to places which can only be reached with difficulty; but with the white elephant some vague notions of a vital Buddha are associated, and there can be no doubt that the marvelous sagacity of the creature has served to strengthen their religious prejudices. Siamese are known to whisper their secrets into an elephant's ear, and to ask a solution of their perplexities by some sign or movement. And, most assuredly, there is more sense and reason in the worship of an intelligent beast than in that of sticks and stones, the work of men's hands.

"'And yet,' continues Sir John, 'after all, the white elephant is not *white*, nor any thing like it. It is of a coffee-color; not of unburnt, but of burnt coffee—dull brownish yellow, or yellowish brown—white only by contrast with his darker brother. The last which reached Bangkok was caught in the woods. The king and court went a long way out into the country to meet him, and he was conducted, with a grand procession, much pomp, music, and flying banners, to the capital. There a grand mansion awaited him, and several of the leading nobility were appointed his custodians. The walls were painted to represent forests, no doubt to remind him of his native haunts, and to console him in his absence from them. All his wants were sedulously provided for, and in his "walks abroad," when "many men he saw," he was escorted by music and caparisoned by costly vestments. His grandest and farthest promenades were to bathe in the river, when other elephants were in attendance, honored by being made auxiliaries to his grandeur. Now and then two sovereigns sought his presence; but I did not learn that his dignity condescended to oblige them with any special notice. But he wanted no addition to his dignity. Every thing associated with majesty and rank bore his image. A white elephant is the badge of distinction. The royal flags and seals, medals and moneys—on all sides the white elephant is the national emblem, as the cross among Christians or the crescent among Turks; and the Siamese are prouder of it than Americans, Russians, Germans, or French, are of their eagles, or Spaniards of the golden fleece. The Bourbon *oriflamme* and the British Union-Jack show but faintly in the presence of the white elephant.'"

WHAT IS DARWINISM? By CHARLES HODGE. 178 pages. Price, $1.50. Scribner, Armstrong & Co.

THE title of this book is a little misleading, although it cannot mislead very far when it is remembered that it emanates from a distinguished Professor of Divinity at Princeton College. A book that should plainly and clearly answer the question "What is Darwinism?" as a matter of pure exposition, and which should also state what it is not, would be extremely useful at the present time. But such a book could only be made by a man of science, free from prejudice, and familiar with the history and bearings of the whole question. The term "Darwinism" is now vaguely used to represent a whole body of doctrines with which it is associated, and of which it is itself but a part; and a book, professing to answer the question implied in this title, should make the discrimination and dispel the vagueness. If the question were given with its ominous implications, as, "What is this horrible Darwinism?" the reader would be set on the right track by the title; for the book is actually an essay on the relations of Darwinism and orthodoxy, and its aim seems to be to establish the position that Mr. Darwin's theory excludes design in Nature, and is therefore atheistic. Dr. Hodge cites various authorities who hold to this view, and he cites others against it. He admits that Mr. Darwin recognizes the agency of the Creator in originating the first germs of life, and he says, "it is conceded that a man may be an evolutionist and yet not be an atheist, and may admit of design in Nature." And yet he is unwilling to let the matter rest here, and the drift of his book seems to be to show that the whole tendency of the inquiry is irreligious and pernicious. He could make out exactly the same case with the doctrine of gravitation as with the doctrine of evolution. The theory of Newton was objected to in its time as dispensing with God, and explaining the movements of matter by a self-sufficing law of inherent attraction. That question is passed by, and men are left at liberty to interpret it in the way they choose. Why not deal with evolution in the same way? The real question is, "What is the truth of the case?" and, until that is worked out and established, it is premature to complicate it with theological difficulties. Nothing is more certain than that it must be investigated by scientific men, on its own merits.

So acute and cultivated a mind as that of Dr. Hodge could not deal with the question without giving interest to it, and his book will well repay perusal. The author evidently aims to be just, and his volume is measurably free from the denunciatory spirit which is too characteristic of controversy. But it must still be said that he is evidently too little familiar with the subject, and some of his statements will surprise the well-informed reader. For example: "When the theory of evolution was propounded, in 1844, in the 'Vestiges of Creation,' it was universally rejected; when proposed by Mr. Darwin, less than twenty years afterward, it was received with acclamation. Why is this? The facts are now what they were then; they were as well known then as they are now. The theory, so far as evolution is concerned, was then just what it is now. How, then, is it that what was scientifically false in 1844 is scientifically true in 1864?" This statement of Dr. Hodge that the doctrine of evolution, as now understood, was propounded by the author of the "Vestiges of Creation" in 1844, is about as correct as the statement of Drs. Burr and Dawson, that it is a plagiarism from the old Greek atheists, Anaxamander, Anaxagoras, Democritus, and Epicurus. The theory of the "Vestiges" was nothing more than a restatement, in popular form, of that of Lamark, and there was no pretension that its author had contributed any thing to it of scientific importance. The real reason, undoubtedly, why the new statement was caught at with such avidity, was the growing conviction that the prevailing explanation of the origin of living forms, by special creation, was indefensible. The "Vestiges" was widely read, but the theory was not accepted, because it did not offer any rational or probable scientific solution of the difficulty. There was, however, a kind of indefinite feeling that the inquiry was in the true direction, and that its fundamental conception might be strengthened and verified by further investigation. This apprehension is well shown by the following extract from a letter of Principal James D. Forbes to Dr. Whewell, in 1846: "You have read, of course, the sequel to the 'Vestiges' . . . . the author of the 'Vestiges,' who is generally believed to be a denizen of modern Athens, has shown himself a very apt scholar, and has improved his knowledge and his arguments so much since his first edition, that his deformities no longer appear so disgusting. It was well that he began to write in the fullness of his ignorance and presumption, for, had he begun now, he would have been more dangerous." In 1859, Mr. Darwin and Mr. Wallace, working independently of each other, developed the principle of Natural Selection, which was the most important single step that had yet been taken to account for the origin and diversities of living forms. That conception, which Professor Helmholtz pronounced "an essentially new creative idea," was soon generally recognized by philosophical naturalists as a valid principle, or natural law, and this gave a new aspect to the whole question. Dr. Hodge's statement, therefore, is one which an instructed scientific man would hardly venture to make.

The Expanse of Heaven. A Series of Essays on the Wonders of the Firmament. By R. A. Proctor, B. A. 305 pages. Price $2.00. D. Appleton & Co., New York.

After a very successful lecturing tour in this country, in which he spoke nearly a hundred times, Mr. Proctor has gone back to England, but he has left us a legacy in the shape of a beautiful little book, "The Expanse of Heaven," which will enable us to go on with the subject, though the living teacher is absent. If Mr. Proctor is not a discoverer in astronomy, and even if he fails to take the highest rank as a lecturer, he is certainly a very able and attractive popular writer upon the subject. That he is thoroughly master of its modern questions there is no doubt, and he certainly possesses in a very marked degree the faculty of presenting them in a pleasing and instructive way. "The Expanse of Heaven" is his latest book, and we think is certain to be his most popular one. It deals with the larger views and grander themes of the science in a very easy and readable manner, and with many touches of poetic feeling that are kindled by the sublimities of the subject. A careful examination of the volume shows that it covers the ground very fully of his lectures in this country, but the statements are far more finished and perfect than any reports of oral discourses could possibly be. We heard his lecture upon the Nebular Hypothesis, but neither the delivery nor the printed sketch will bear comparison for a moment with the two papers in this volume entitled "How the Planets grew." Of the thirty topics considered in the book, and selected with reference to their general interest, "The Sun," "The Evening Star," "The Ring-girdled Planet,' '" Visitants from the Star Depths," "The Earth's Journey through Showers," "Worlds ruled by Colored Suns," "The Depths of Space," and "The Drifting Stars," are perhaps the most attractive, although different readers will have different opinions upon this point.

The Philosophy of Herbert Spencer: Being an Examination of the First Principles of his System. By B. P. Browne, A. B. 283 pages. Price, $1.25. New York: Nelson & Phillips.

This is a swaggering polemic, designed to be in the interests of religion, and written by a man equally and eminently self-conscious and unscrupulous. It will be regarded as a masterly reply to Mr. Spencer by those who know nothing of that thinker's doctrines, for, by the aid of misrepresentation and setting up men of straw, he achieves a succession of the most brilliant logical victories. In the last *Bibliotheca Sacra*, Prof. Mears, of Hamilton College, gives an article to the adverse criticism of Mr. Spencer; but of the man he says: "It is a long time since purely English philosophy has produced so able, so comprehensive, and so daring a thinker as Herbert Spencer." In his works "we have some of the clearest and most forcible statements of opinion upon great and abstract topics to be found in the English language. If the truth must have opponents, it is just such opponents we prefer to see and to meet—frank, outspoken, unreserved." This is the general judgment that is passed upon Mr. Spencer by eminent thinkers who have studied him, whether they agree with his views or not. But Mr. Browne is of a different opinion. His pages are filled with expressions of contempt, from which we gather that Mr. Spencer is such a transparent fool, and such an obvious knave, that his critic's task is a very light one; and we wonder that he condescended to bring his intellect down to such trifling work. Buffoonery, puerility, absurdity, thimble-rigging, jugglery, sleight-of-hand, are samples of the terms used to characterize Mr. Spencer's reasoning, while his philosophical method is said to be "a purely hap-hazard system," "a miracle of confusion and absurdity," which "takes an insane delight in knocking out its own brains." We observe that the theological press commends this book to its readers as putting an end to

Spencer. Can it be that they are really in such a desperate way in that camp?

Annual Record of Science and Industry for 1873. Edited by Spencer J. Baird. New York: Harper & Bros. 714 pp., 12mo. Price $2.00.

This volume presents a very large amount of valuable and interesting information in compact form, being in fact a history of progress in science and art for the year. The main part of the book is prefaced with a brief summary of the year's progress. The matter is presented in divisions named according to their nature, in general scientific terms, as Mathematics and Astronomy, Terrestrial Physics, and Meteorology, etc. Much important knowledge bearing directly on the ordinary affairs of life is to be gleaned from the divisions on Agriculture and Household Economy. For instance, the latter contains some valuable facts about lightning and lightning-conductors. Chimneys should be kept clean, as one lined with a thick layer of soot is dangerous, being apt to conduct the current of electricity into the house. The costly copper rods now so popular are condemned, and the ordinary galvanized iron wire, No. 4, recommended instead. A conductor, to be effective, should have no joints nor acute angles, and the lower end should rest in the ground, while the upper should be tipped with a gilded or polished point. Conductors are also likely to become impaired from use, and therefore need occasional examination and repairing. In the division of Materia Medica, a simple and effectual method is given for distinguishing real from apparent death. This is in simply tying a tight ligature around a finger of the supposed corpse; if death is only apparent, the end of the finger will shortly become red.

About meteors and comets, we are told, Prof. Proctor has concluded that comets are detached masses of matter thrown off by planets like Jupiter, Neptune, and Uranus, while in a molten condition. Meteors are fragmentary parts of disintegrated comets. The inflammatory character of meteors has also been established. In May, 1873, two men in North Germany observed a falling meteor strike against a church-tower, and rebound with loud detonation to a house-top. The house soon became enveloped in flames, which spread and destroyed several adjoining buildings. The most startling statement, probably, comes from Secchi, the great Italian astronomer. This is that the sun varies in size. Secchi's hypothesis is, that the sun's photosphere as seen by us is a gaseous envelope, continually, and perhaps periodically, changing in apparent size.

The Kindergarten Messenger. Edited by Elizabeth P. Peabody. Monthly, 24 pages, $1.00 per year. 19 Follen Street, Cambridge, Mass.

The name of Froebel is becoming as familiar in connection with a method of child-culture called the Kindergarten, as was the name of Pestalozzi a few years ago in connection with the method of school instruction by objects. Froebel's course, like the college curriculum, runs through four years, from three to seven, of the child's life. His idea is not only to furnish objects so as to influence early impressions, but to combine action with observation, and make play-studies available in the first steps of education. Froebel, motherless from his earliest recollections, and then having the experience of a step-mother who neglected him, was drawn by a powerful sympathy to children, whom he thought are generally neglected, and was moved to do something to beautify and enrich their opening lives. That his devices were ingenious, and his own practice probably successful, may be freely admitted, and it must be acknowledged also that he dedicated himself to a noble work; but to what extent he struck the true principles of the management of children is not so clear. Certain it is that many of his followers made but sorry work in their endeavors to carry out his system. Long interested in this question of the first steps in education, and having heard much of Froebel's new dispensation, we sought out a Kindergarten school in London several years ago which was conducted by teachers trained at the feet of the master. The method was there in all its novelty, and it was obvious enough that it contained many excellent features; but, alas! the trail of the school-room was over them all. It had become a routine, and although marching, singing, and various activities, were a part of it, there was the same mechanical listlessness with which we were familiar under the old ways. We do not generalize from this single instance, but we gather from an examination of Miss Peabody's tracts that there has been not a little rough and crude work in the attempt to carry out Froebel's plan. But the merit of this reformer is independent of the perfection of his method. He has done the world incalculable service by fixing its attention, first and clearly, upon a subject of the greatest importance, and the attempts to carry out his method can hardly fail to lead to something better. Miss Peabody is among the pioneers of the movement in this country, and she has worked like a saint in the cause. Her little periodical deserves to be liberally sustained. Kindergarten schools are springing up in various places, and their managers will need all the enlightenment they can get. But, whether schools be established or not, the literature of the subject abounds in valuable suggestions that may be made available in home education. For it is here after all that the main interest must centre, and to us the highest value of the movement is its possible result in giving us more competent and better-instructed mothers. We note not without apprehension the growing disposition to invoke State agency in the establishment of this new order of educational institutions. Should this plan succeed, and the new schools be, moreover, subjected to the principle of "compulsory education," as by the logic of the case they must, the situation will become interesting. To the extent in which the Kindergarten idea becomes the rival of family nurture and is resorted to by mothers to escape their responsibilities, it will be injurious; but, in so far as it has the contrary effect and educates mothers as well as children, it will prove a boon to society.

First Lessons in the Principles of Cooking. By Lady Barker. London: Macmillan & Co. 101 pp., 18mo, price 50c.

This little book treats of the chemical composition of food; the effect on the human body of the different substances used as such; of the modes of preparing certain kinds of food in conformity with their action; and of the principles of diet. In the first part is shown what elements are necessary to make animal or vegetable substances fit for food, and what substances possess those elements in the highest degree. The second part explains easy and economical methods of making bread, cooking vegetables, meats, etc., and building and keeping up kitchen-fires. The third part enforces the truth that the body is benefited not by the quantity of food eaten, but by the quantity digested, and goes on to show what kinds of diet are best adapted to the digestive organs of persons in different occupations. The book contains much information that is valuable to the housekeeper.

Fuel. By C. William Siemens, D. C. L., F. R. S., and John Wormald, C. E. New York: D. Van Nostrand. 81 pp., 18mo, price 50c.

This work comprises two addresses delivered before the Council of the British Association. The first part discusses the nature of fuel, the source whence it is derived, the best methods of using it economically, the coal question of the day, and solar heat. Fuel is defined as any substance capable of entering into combination with another substance and giving rise to heat in the act, and it is shown to be derived from solar energy acting upon the surface of our earth. The subject is handled in a scientific manner, and has a direct practical bearing on economy of the use of fuel in manufactures, transportation, and the household. The second part ostensibly compares the value of artificial fuels with coal, but is little more than an enumeration of the various attempts that have been made within the past hundred years to produce an artificial fuel.

We are informed by the *Boston Globe* that the forthcoming work of Mr. John Fiske, to be simultaneously published in England and this country, is nearly completed, and will be issued early next autumn. Those who have been interested in his lectures will be gratified to learn that these are to be reproduced in a carefully-revised form, with much new matter which will give his work a comprehensive character It will be in two volumes, comprising nearly a thousand pages, under the title of "Outlines of Cosmic Philosophy based on the

Doctrine of Evolution." It is a much less exhaustive and more popular treatise than Mr. Herbert Spencer's yet unfinished "System of Synthetic Philosophy," upon which it is mainly founded; but it embraces a wider range of subjects than is discussed by Mr. Spencer. Those who are familiar with Mr. Fiske's remarkable powers of exposition and grasp of thought will need no assurance as to the interest of the work, and to others we may say that it will undoubtedly be the most valuable introduction to modern scientific philosophy that has been yet produced. Mr. Fiske is expected to return from Europe about the last of June.

A Popular Key to the Birds, Reptiles, Batrachians, and Fishes of the Northern United States, east of the Mississippi River. By Prof. David S. Jordan, M. S., and Balfour H. Van Vleck. Appleton, Wis. 108 pages. Price, 75 cents in paper covers; $1.25 in flexible cloth.

This is a convenient pocket manual, designed to enable collectors readily to ascertain the names of the birds, reptiles, and fishes, occurring in the region indicated.

PUBLICATIONS RECEIVED.

Diffractive Spectrum Photography. By Henry Draper, M. D. Pp. 9.

Notes on Microscopic Crystals, and Observations on Unionidæ. By Isaac Lea, LL. D. Pp. 24.

The Protoplasm Theory. By Edward Curtis, A. M., M. D. Pp. 23.

The Medical Colleges, the Medical Profession, and the Public. By Standford E. Chaillé, A. M., M. D. Pp. 24.

Materialism, its History and Influence on Society. By Dr. L. Büchner. New York: Asa K. Butts. Pp. 28.

The Essence of Religion. By Ludwig Feuerbach. New York: A. K. Butts. Pp. 75.

The Vermiculetes. By Josiah P. Cooke, Jr. Pp. 32.

Review of "Darwin on Expression." By Alexander Bain. London: Longmans, Green & Co. Pp. 18.

Transactions of the American Society of Civil Engineers. Pp. 50.

Seizing Books and Papers under the Revenue Laws. Published by the New York Chamber of Commerce. Pp. 56.

Report ou the Incurable Insane in Illinois. By Fred. Wines. Pp. 11.

Community of Disease in Men and Other Animals. By W. Lauder Lindsay, M. D. Pp. 37.

Lecture on Buddhist Nihilism. By Max Müller. New York: A. K. Butts. Pp. 16.

Thirteenth Annual Report of the Brooklyn Park Commissioners. Pp. 47.

A Third Catalogue of Seventy-six New Double Stars. By S. W. Burnham, Esq. Pp. 14.

The Money Problem. By Henry Bronson. Pp. 28.

Bulletin of the Minnesota Academy of Natural Sciences. 1874. Pp. 150.

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MISCELLANY.

A Science Minister for England.—There is an agitation now going on in England for the appointment of a responsible government minister, whose duty it shall be to look after the interests of science and scientific research and education, and to take charge of the scientific institutions of the country. A writer in the *Times*, Colonel Strange, whose views are approved by *Nature*, calls attention to the fact that, though "there is more individual enterprise in England than in any country in the world," yet the English are being rapidly outstripped by other nations. At present, the various scientific institutions maintained by the state are under no less than seven different governmental departments, all of which have other matters besides science to attend to. The writer names six observatories, of which one, Greenwich, is under the Admiralty; another, Edinburgh, under the office of Works; a third, at the Cape of Good Hope, under the Colonial office; and the rest under the India office. The other departments of state which assume to direct scientific work are the Privy Council and Board of Works, and Board of Trade. Colonel Strange favors the creation of a Science Minister, under whose control all these scientific institutions shall be placed. "Let this be done," says he, "and we should cease to witness the farce of consulting the Chancellor of the Exchequer about observing eclipses of the sun, the prime-minister about scientific arctic expeditions, and the Treasury about tidal reductions. We should perhaps, too, then perceive that overworked law-officers are not the best managers of a great, or what should be a great, technical museum, and that fifty irresponsible gentlemen, however eminent individually, ought not to be intrusted with the grandest collection of art and natural history in the world."

The Acoustic Properties of the Atmosphere.—The coasts of the British Isles are exceedingly beset with fogs, which make navigation in their vicinity a very dangerous business. During a period of ten years these fogs were the cause of 273 shipwrecks, many of which were attended with serious loss of life. As signals in thick weather, lights are almost worthless; sounds have, accordingly, been substituted, and instruments for producing them, such as bells, fog-horns, steam-whistles, etc., have been set up and employed at numerous stations. But it has been observed that the distances at which these sounds could be heard were extremely variable; that while at one time they would give warning seven or eight miles away, at another they were inaudible at half the distance, and perhaps totally useless for the purpose intended.

The authorities last spring requested Prof. Tyndall to look into the matter, which he did, and, as is usual with him, when he undertakes an inquiry, with interesting and valuable results. Selecting the South Foreland Cliff, in the Straits of Dover, as the site of operations, he began a series of experiments to test the distances at which various sounds could be heard. The instruments used for producing the sounds were, trumpets sounded by air, whistles sounded by steam, the steam-siren, and cannon. The observations were continued at intervals from the 20th of May last to the 25th of November. At different times sounds of like intensity were heard at widely-varying distances. For example, a sound that at one time could be heard only two miles, could at another time be heard twelve miles. On one occasion the sound of the steam-siren was heard fifteen miles. On the morning of June 3d, the sky being of a stainless blue, and the sea calm, the sound of a cannon could not be heard beyond two miles, and a "mortar fired with a three-pound charge yielded only a faint thud; it was mere dumb-show on the Foreland." The air was optically clear, but opaque and impenetrable to sounds. On other occasions, during fog and driving rain, the sounds could be heard at various distances, as four, five, seven, and nine miles; and once, when the air was hazy, they were heard twelve and three-quarter miles. The inference is, that the transmission of sound through the atmosphere is not affected by fogs and rain; the air during their prevalence may be opaque to sound, but not on that account. The movement and arrest of sound in the air depend on other conditions than the mere presence of fog or rain, and these conditions may exist when the atmosphere is wonderfully clear to the eye. What, then, becomes of the enormous volumes of sound produced by cannon and the steam-siren, seeing that they are neither transmitted nor annihilated? In order to determine this question, Prof. Tyndall and his companions took a position on the shore overlooking the sea, and there for the first time demonstrated by experiment "the reflection of sound from aërial surfaces. From a perfectly clear air the sounds came back in echoes. They reached us as if by magic from absolutely invisible walls." Now, what are the conditions which thus intercept the sound-waves? The phenomenon is clearly due to a non-homogeneous atmosphere produced by inequalities of temperature, and the unequal distribution of vapor. "As I stood upon the deck of the Irene," says Prof. Tyndall, "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 mixture, I considered in the highest degree improbable. It would be sure,.I thought, to streak and mottle the atmosphere with spaces in which the air would be in different degrees saturated. . . . At the limiting surfaces of these spaces, though invisible, we should have the conditions necessary to the production of partial echoes and consequent waste of sound." This philosophical explanation Prof. Tyndall was able to verify. On one occasion, when the air was opaque to sound, a cloud arose and threw its shadow over the sea. Some increase in the intensity of the sounds was noticed; but, with decline of the sun, it was more obvious, until at length the signal-sounds were heard at a distance of twelve and three-quarter miles, when at first they were inaudible at two miles. The increase of distance at which the sounds were distinctly heard was gradual with decline of the sun, or, what is quite obvious, with increase of homogeneity of the atmosphere. This was fully shown on another occasion, when, during a violent rain, the transmission of sounds was greatly increased, so that they could be heard more distinctly at seven and one-half miles than at five miles previous to the storm.

The Anderson School at Penikese.—The Anderson School of Natural History will open this year on Tuesday, July 7th, and close on Saturday, August 29th. During the session, Prof. Mayer, of the Stevens Institute, Hoboken, will deliver a course of lectures on Physiological Physics. Mr. Theodore Lyman, of the Cambridge Museum of Comparative Zoology, will give a few lectures on Pisciculture. Lectures will also be delivered by Dr. W. S. Barnard, of Ithaca, N. Y., on Protozoa; Prof. Jordan, of Appleton, Wis., will take charge of the instruction in Marine Botany. Mr. Alexander Agassiz will have charge of the instruction on Radiates and Embryology; Dr. A. S. Packard, Jr., of Salem, Mass., on Articulates; Prof. B. G. Wilder, of Cornell, on Vertebrates; Prof. E. S. Morse, of Salem, and Prof. C. E. Hamlin, of the Museum of Comparative Zoology, on Mollusca; Mr. T. W. Putnam, Director of the Peabody Academy of Science, on Fishes; Mr. Edwin Bicknell, of the Museum of Comparative Zoology, on Microscopy. Instruction in Drawing will be given by Mr. P. Roetter, of the Museum of Comparative Zoology. Dr. Packard and Mr. S. W. Garmon will take charge of the dredging expedition, and the laboratories will also be under the supervision of Mr. Garmon.

Scientific Apparatus. — While it cannot be questioned that the popular demand in this country for appliances with which to illustrate the first principles of physical science is well met by several makers of philosophical instruments in this and other cities, it is still true that, in the higher branches and grades of scientific illustration, our chief dependence for efficient apparatus is upon English, French, and German makers. In the two great departments of Electrics and Optics this is especially observed, and we take pleasure in commending to the notice of professors and teachers of science the card of Mr. Browning, of London, in our advertising page this month. Mr. Browning is an honored Fellow of the Royal Astronomical Society of England, and, what is more to the present purpose, he is the successful maker to the Royal Society, and to the leading English observatories, of the instruments they employ in their great and varied work. In the construction of spectroscopes of every sort he has, perhaps, no equal, certainly no superior.

Soaring and Sailing of Birds. — Mr. Belt, describing the movement of a pair of black vultures sailing on the wind, says: "Like all birds that soar, both over sea and land, when it is calm the vultures are obliged to flap their wings when they fly; but when a breeze is blowing they are able to use their specific gravity as a fulcrum, by means of which they present their bodies and outstretched wings and tails at various angles to the wind, and literally sail. How often when becalmed on southern seas, when not a breath of air was stirring, have I seen the albatross, the petrel, and the Cape-pigeon, resting on the water, or rising with difficulty, and only by the constant action of their long wings able to fly at all! But when a breeze sprang up they were all life and motion, wheeling in graceful circles, now presenting one side, now the other to view, descending rapidly with the wind, and so gaining velocity to turn and rise up again against it. Then, as the breeze freshened to a gale, the petrels darted about . . . . poising themselves upon the wind with as little effort as a man balances himself upon his feet."

An Aged Pelican.—*Land and Water* contains an interesting "obituary notice" of Jack the Pelican, for upward of forty years an inhabitant of the Dublin Zoological Gardens. This fine specimen of the genus *Anser* was presented to the gardens in 1831, being then full grown, and supposed to be seven or eight years old. Jack was generally about the first specimen which was introduced, or rather introduced himself, to the notice of visitors, as he was seldom shut up in a cage, but walked or waddled about where he pleased. He usually treated strangers with sovereign contempt, hardly deigning to get out of their road; but when seized, and his beak opened to show his curious little cleft tongue, which lay at the bottom of the pouch, under the bill, his eye, usually a splendid ruby, or rather carbuncle color, got red as a coal, with anger, at the indignity. His plumage was always in the most beautiful order and the most brilliant white, except about the head, where the soft, downy hackles assumed a pinky hue. Curiously enough, he never went into the water, except occasionally for the purposes of ablution, when he would duck and wash himself all over; then, returning to land, squeeze the water out of his feathers with his bill, and stand in the sun to dry. But he never seemed to swim for pleasure or to fish, in which respect he differed from the three junior members of his tribe, also locked up in the gardens. Another peculiarity of his was that he would never touch any food but fish. The others soon learned to eat and relish horse-flesh on occasion, but Jack stood out stanchly, and fish, and fish only, he would have, at whatever cost, all attempts at deceiving him being in vain. Jack knew his friends and enemies well, and when he first came, and until the death of his original owner, a Mr. Egan, it was absurd to see the way he attached himself to that gentleman, running to meet him at the gate, and never leaving his side. For some time before his death he subsisted on a stimulating diet of live eels and whiskey-punch.

Species of Dicotyledonous Plants.—The number of that great section of flowering plants which, when the seed sprouts, give off two ledons, or embryonal leaves, is shown in the "Prodromus" of De Candolle, recently finished in seventeen volumes, to be very large. Not counting the eminent men that have given earnest work on it as specialists, it has had the conduct of three generations of De Candolles, the grandfather, Augustin, who dying bequeathed it to his son Alphonse, who in like manner left it to his son Casimir. The first and the second wrought together for years, as did also the second and the third. The work describes 5,134 genera and 58,975 species, which is probably not more than one-half the number of species of dicotyledonous plants existing. The principal natural orders described are:

	Genera.	Species.
Compositæ	911	8,561
Leguminosæ	2[illegible]8	8,858
Rubiaceæ	225	1,888
Euphorbiaceæ	191	3,272
Scrophulariaceæ	176	1,879
Umbelliferæ	160	1,016
Acanthaceæ	154	1,481
Asclepiadaceæ	134	1,018
Labiatæ	122	2,401
Cruciferæ	100	[illegible]88
Solanaceæ	65	1,725

The most numerous genera are as follows:

	Species.
Solanum	915
Euphorbia	751
Senecio	601
Croton	461
Phyllanthus	447
Erica	429
Salvia	410
Peperomia	389

The Pneumatic Dispatch.—The following description of the London "Pneumatic Dispatch," for the conveyance of small parcels of goods from place to place, we take from the *Times:*

"The pneumatic tube extends from the London and Northwestern Railway Station at Euston Square, to the General Post-Office in St. Martin's-le-Grand. The central station is in Holborn, where is also the machinery for effecting the transit of the trains. Here the tube is divided, so that in effect there are two tubes opening into the station, one from Euston to Holborn, and the other from the Post-Office. The length of the tube between Holborn and Euston is exactly a mile and three-quarters. The tube is of a flattened, horseshoe section, 5 feet wide and 4 feet 6 inches high at the centre, having a sectional area of 17 square feet. The straight portions of the line are formed of a continuous cast-iron tube, the curved lengths being constructed in brick-work, with a facing of cement. The gradients are easy; the two chief are 1 in 45 and 1 in 60; the sharpest curve is that near the Holborn station, which is 70 feet radius. The tube between Holborn and the Post-Office is 1,658 yards in length, and is of the same section, and similarly constructed to the first length. Two gradients of 1 in 15 occur on the Post-Office section, but this steep inclination is in no way inimical to the working of the system. The Holborn station is situated at right angles to the line of the tubes, which are therefore turned toward the station into which each opens. All through-trains, therefore, have to reverse there, and this is effected in a simple manner by a self-acting arrangement.

"The wagons, or carriers, as they are termed, weigh 22 cwt., are 10 feet 4 inches in length, and have a transverse contour conforming to that of the tube. They are, however, of a slightly smaller area than the tube itself, the difference—about an inch all round—being occupied by a flange of India-rubber, which causes the carrier to fit the tube exactly, and so to form a piston upon which the air acts. The machinery for propelling the carriers consists of a steam-engine having a pair of 24-inch cylinders with 20-inch stroke. This engine drives a fan 22 feet 6 inches in diameter, and the two are geared together in such a manner that one revolution of the former gives two of latter. The trains are drawn from Euston and the Post-Office by exhaustion, and are propelled to those points by pressure. The working of the fan, however, is not reversed to suit these constantly-varying conditions; it works continuously, the alternate action of pressure and exhaustion being governed by valves."

NOTES.

Dr. James McNaughton, President of the Albany Medical College, and Professor of the Practice of Medicine, is supposed to be the oldest medical lecturer now in active service. He has delivered fifty-three annual courses of lectures, and, during this half-century of work, has not missed a dozen lectures or been confined to the house a week by sickness. He is seventy-seven years old, and is hale and active.

The white-willow, it is said, has been used very successfully in Iowa for fencing. C. B. Mendenhall, of Marshall County, has about thirteen miles of white-willow fence, of from three to seven years' growth, of which above half will turn cattle. He has also a grove of white-willows, set out about six years ago, which is considered to be worth about $500 per acre.

A Western paper reports that a spaniel, named Curly, performs the duties of mail-carrier between Lake of the Woods, Dakota, and the Minnesota line, twelve miles distant. Letters and papers are placed in a sack and tied about the dog's neck; he is told to go, and never fails to reach his destination. On his arrival, the mail is overhauled, the dog is treated to a good dinner, and started back again.

Philadelphia possesses a very energetic Zoological Society of about 500 members. Thirty-five acres of ground in Fairmount Park have been assigned to them for a zoological garden, though for the present they will occupy but ten acres. Within the last six months the society has laid vulcanite walks through the garden, built a monkey-house, and made other provision for a large number of beasts and birds from all parts of the world. A small collection has already been made, which will this summer be added to by importations from Africa, Asia, and Australia. There will be a large aquarium, and it is intended to institute courses of popular lectures on Natural History.

At a meeting of the Philadelphia Academy of Sciences, Mr. Meehan exhibited a small Norway spruce, the branches and leaves of which were of a golden tint. He said that, when plants had little food, or lost their fibres in wet soil, and thus could not not make use of food, the yellow tint was generally seen in their leaves. Judging that something analogous must have happened to the spruce, he, on examination, found its roots thickly enveloped by the mycelia of a fungus, which destroyed the young rootlets as fast as they were developed. Only a few trees in his grounds had been attacked two years ago; but during the past two seasons the fungus had spread underground from plant to plant, till now there were over one hundred diseased. He had supposed the fungus to be of the microscopic kind; but in October last the mycelia developed into a brown *agaric* with a pileus about two inches broad, but the exact species of which he could not determine. He suggested that, as the phenomena in the case of what is known as "peach-yellows" were of the same nature, those who had the opportunity to examine might find the roots attacked by a fungus in the same way.

It is stated in the Cincinnati *Gazette* that Mr. S. A. Bell, of Plainfield, Ohio, has found under an ancient mound a quantity of fragments of bones of very young children, with the tooth of a rodent animal, which had been used as a neck ornament. These relics were discovered in a large bed of coal and ashes, indicating that the fire had covered a space of twenty-five feet in diameter. It is supposed that the children were the victims of some bloody sacrificial rite. The mound under which the relics were buried was of medium size, and its materials had been transported from a considerable distance, and from several different points.

It is universally admitted that asphalt makes a perfect pavement in all respects, except that it is very slippery under certain conditions, that is, when covered with mud. Hence, if an economical method of keeping the surface clean can be devised, this kind of pavement is to be preferred to all others. Impressed with this belief, the London Commissioners of Sewers have directed experiments to be made as to the best mode of cleansing, and the several asphalt companies have united in offering a premium for any improved plan of effecting this purpose.

Analysis of asparagus-shoots, by A. Vogel, shows that the extremities contain no sugar, though the stem, three or four inches below, contains 1.7 to 2 per cent. The explanation is, that the sugar is used up in the formation of cells, which goes on actively in the shoots. The same is the case with potato-shoots.

Absolutely pure iron is said to have been produced by a Russian chemist, by means of the galvanic battery. During the process, a large quantity of hydrogen was disengaged from the ordinary iron used. The pure iron is a silver-white metal, very malleable and ductile, and so soft as to be readily cut with a pair of scissors. It is very different from iron which has hitherto been supposed to be pure. It oxidizes very rapidly, and water is decomposed by it by the rapid absorption of oxygen.

It is proposed to apply the sand-blast to the quarrying of slate, either for slabs or roofing-slates, thus preventing much of the waste inevitable under the present imperfect methods of quarrying. As this waste frequently amounts in weight to as much as nine times the weight of the marketable article produced, it will be seen that there is a wide margin for the profitable use of this invention. The process is also applicable to quarrying stone, and for cutting hard rocks in railroad tunneling.

The "quick-signal railroad lantern" is a very useful contrivance, and destined to supersede the common lantern on all railroads. This lantern is furnished with a mechanism whereby in the fraction of a second a white light may be changed to ruby, and *vice versa*. This is effected by means of a small inverted cup of ruby glass which surrounds the flame, having of course an opening above for the escape of smoke. The cup may be depressed beneath the flame, and then the lantern gives a white light; or it may inclose the flame, and then the light is red.

Harness and other articles of leather which are injuriously acted upon by the ammoniacal exhalations common in stables may, according to Prof. Artus, be thoroughly and effectually protected by the addition of a little glycerine to the oil or blacking with which their surfaces are treated.

Iron is not volatile, except at very high temperatures, like gold and platinum. Dr. Elsner, director of the Berlin Porcelain-Works, has tried the experiment of subjecting a small piece of iron, in an unglazed crucible, to a long-continued exposure to a temperature of over 3,000 Cent., when he was distictly enabled to recognize minute needles of crystallized iron on the cover of the crucible, the result of vaporization.

Cut flowers may be kept fresh for a fortnight, it is said, by dissolving sal-ammoniac or chlorhydrate of ammonia with the water in which the stems are put, in the proportion of about 75 grains per quart of water. The experiment is one which can be easily made.

Dr. THOMAS YOUNG.

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TELESCOPIC RESEARCH ON THE NEBULA OF ORION.

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IT is well occasionally to cast our eyes back over a series of labors, in order that we may rightly judge of our progress.

Rough comparisons alone will not tell us: it is easy to contrast Galileo's piece of lead-tubing, having a lens in each end of it, with the gigantic telescopes of to-day; but we hardly learn much from such a comparison. The extremes of the series are too far removed; to get a just idea of the terms between, the comparisons must be made at shorter intervals.

If we can select some celestial object, which has been telescopically studied for a long period, we may, by contrasting the results obtained at different times, gain some accurate notion of the progress made, and of the way in which it was made.

This latter idea is of some importance when we consider that the day of startling discoveries is over. When Galileo found the four moons of Jupiter, the whole world of men of learning was astounded; and still more wonderful was his discovery of the ring of Saturn—that is to say, of the existence of a ring of Saturn—a portion of which, showing on each side of the planet, gave to Saturn the "tri-corporate" aspect which Galileo describes in a letter to his friend Kepler.

Even the discovery of Uranus by Sir William Herschel, in 1789, was by no means an extraordinary event, although it was received with enthusiasm in all Europe, for Herschel's examination of the heavens was done with the aid of an instrument which could not fail to show Uranus with a sensible disk, if the planet should enter the field of his telescope.

The discovery of the first asteroid, Ceres, on the 1st day of January, 1801, by Piazzi, was received with some surprise, but these small bodies have lately become quite common (there being now 135 of them known), and certainly we in America, who have Peters and Watson among us, have no cause to wonder at such discoveries.

Neptune was discovered first by two theoretical astronomers in their studies, and the delight with which the news of the actual discovery was received was a tribute to the power of pure analysis, and in nowise contributed to the glory of telescopic research.

The startling discoveries, as we have seen, were reserved for the early astronomers, who first found the new country, leaving their successors to accurately map it out. The lesson of patience which can be learned from the labors of these successors is no mean one. To this patience, supplemented by a skill which usually must be of a high order, we owe the later discoveries of the telescope, such as the finding of the eighth satellite of Saturn (by Bond and Lassell), and of the two interior moons of Uranus (Lassell, 1847 and 1851), and of the satellite of Neptune.

There is hardly an object in the whole heavens—planets, of course, excepted—which has been so thoroughly and faithfully studied as the Great Nebula in Orion. And this nebula has a history which will well repay a study somewhat in detail. We shall, in comparing the different work already done upon it, arrive at a very good idea of the progress of telescopic astronomy itself, since, for over 200 years, the details of this nebula have been a subject of solicitude to a great number of eminently skillful astronomers, aided by the best telescopes of their time.

The nebula was discovered by Huyghens in 1656, and in our own century it has been studied by the great reflectors of Herschel and Rosse, and by the refractors of Cambridge, Pulkova, and Rome, in the hands of Bond, Struve, and Secchi.

The place of this nebula in the heavens is easily to be found by any one tolerably familiar with the aspect of our winter sky.

The constellation of Orion is a well-known and brilliant asterism, and very conspicuous among the other stars of the group are the three stars which constitute the "belt." Below these are three others, in nearly a straight line, and these are known as "the sword:" the northern star of these is C Orionis; the middle one is θ (Theta) Orionis; and the southern is ι (Iota) Orionis; it is of the nebula surrounding θ Orionis that we wish to speak.

Flamsteed, astronomer-royal of England, marked θ Orionis in his catalogue of stars, as of the fourth magnitude, and to the naked eye it so appears.

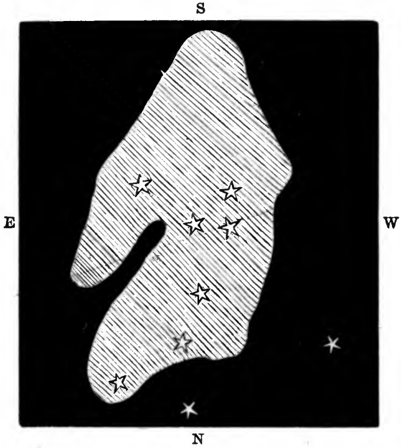
But, on examination with a telescope, this star is seen to be not single, but multiple. When Huyghens, in 1656, turned his newly-constructed telescope to it, he saw *three* stars, and these were surrounded by a cloud-like mass—the nebula.

The figure which he printed in his "Systema Saturnium" is given (Fig. 1, p. 259), together with the figure of the French astronomer, Le Gentil, which was drawn in 1758, and which may be found in "Histoire de l'Académie," 1759. This is Fig. 2.

The fourth star was, however, seen by Domenique Cassini before Le Gentil's drawing was made.

Not a little is to be learned from these figures, which we must try to keep in mind, as the region to which they refer is the central and most interesting portion of the great nebula. We can see, first, that

FIG. 1.



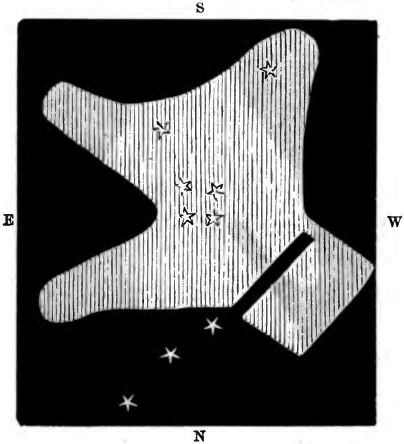
NEBULA ORIONIS. (Huyghens, 1656.)

there is an entire absence of shading in the portion of the nebula drawn; the outline of nebulous matter is simply filled in by shading of a uniform tint. It is much to be regretted that it is impossible to print here the exquisite engraving of this nebula, made from drawings by Prof. G. P. Bond, director of Harvard College Observatory, in 1865. In this drawing one hardly knows which to admire most, the accuracy and painstaking skill of the astronomer, or the exquisite tact of the engraver. There are very few nights so fine, and there are very few instruments so perfect, as to give a view of this nebula as good and as detailed as may be had from this engraving alone.

But we must be content with referring to the plate ("Annals of Harvard College Observatory," vol. v.) for the details of the *nebulous* portions of this region, and we must content ourselves with reproducing only the stars of the surrounding space. It is true that especial attention has been paid by some astronomers to the smaller stars in this nebula; while some, as Herschel the younger, have evidently bestowed more care upon the grades of light in the nebula itself; but, on the whole, we shall find that the number and faintness of the small stars, seen by any astronomer in any one limited region, are a very fair test of his own assiduity, and of the excellence of his telescope.

It will be seen that Le Gentil has made of the star θ Orionis *four* stars, adding one to the number seen by Huyghens. These four are the celebrated trapezium of Orion, and they constitute one of the most remarkable multiple stars of the whole heavens.

Fig. 2.



Nebula Orionis. (Le Gentil, 1758.)

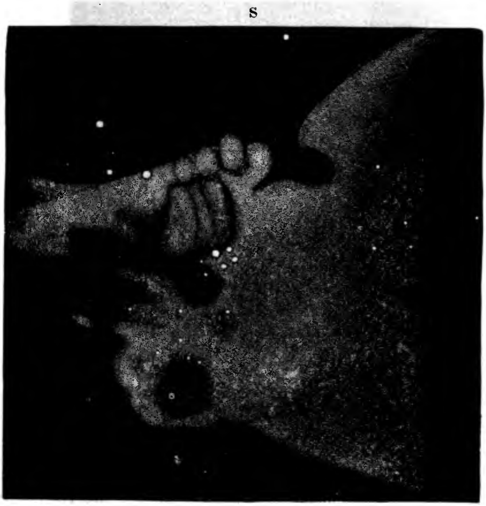
Messier, who examined the nebula carefully, in 1771, gives these four stars, and a very good drawing of the nebula, in "Histoire de l'Académie," 1771. This work was extremely creditable, considering his instrumental means, and the comparatively short time spent upon it.

This trapezium was destined to become famous, for, in 1826, the elder Struve found, close to one of the large stars of the trapezium, a small companion—the "fifth star." This was for a long time considered as a delicate test for an instrument; but, in December, 1832, Herschel found yet another small star—the "sixth star." The trapezium now was seen (with suitable means) as in Fig. 3.

Let us follow the history of the whole nebula for a time, and we shall see what additions have been made to our knowledge of the space near this remarkable group.

It may be here remarked that the grouping of these six stars is in all probability not accidental, but that they are physically connected: Struve has shown that the chances are 9,000 to one against any two stars from the first to the seventh magnitude, inclusive, falling within 4″ of each other if the stars were fortuitously scattered over the whole heavens to begin with. And, further, he has shown that the chances are 170,000 to one against any such stars, if fortuitously scattered, falling within 32″ of a third so as to form a triple star. The chances against any such grouping as that seen in the trapezium of Orion are enormously greater than the numbers given above, and the inference is irresistible that these stars are in some way physically connected. We shall see, too, that it is also probable that these stars are in some unknown way related to the surrounding nebula.

FIG. 3.



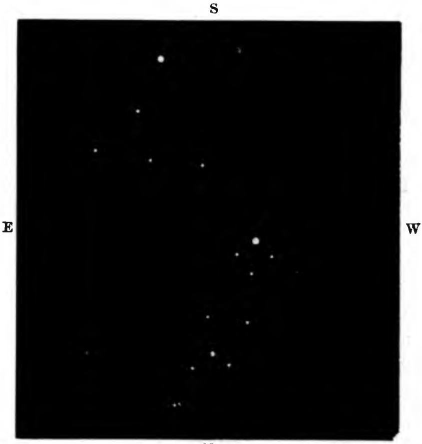
CENTRAL AND MOST BRILLIANT PORTION OF THE GREAT NEBULA IN THE SWORD-HANDLE OF ORION, AS OBSERVED BY SIR JOHN HERSCHEL IN HIS 20-FOOT REFLECTOR AT FELDHAUSEN, CAPE OF GOOD HOPE (1834 TO 1837).

In 1811 Sir William Herschel was led to suspect changes in the form and brightness itself: an inference which he probably drew from a comparison of the early drawings with the appearance of the nebula as he saw it in his own reflectors; and in 1824 the younger Herschel made a drawing of the nebula and the stars immersed in it, as shown by his 20-foot reflector.

This drawing and a description of the nebula are given in "Memoirs of the Royal Astronomical Society," vol. ii., p. 489, and a copy of the drawing, so far as the small stars immediately about the trapezium are concerned, is given in Fig. 4.

The recession of the nebula from the stars of the trapezium is here noted for the first time, so far as I know: this recession is a real phenomenon, and is thus spoken of by Sir John Herschel: "The nebula, which is very bright in the parts surrounding the trapezium, seems (whether by the effect of contrast with the dazzling light of these stars, or from a real deficiency in nebulous matter) to have retreated from immediate contact with them, so that they appear in some degree insulated and with a darkness about them. This would agree with the idea of a subsidence of the nebula into the stars by gravitation; but it is probably only a deception."

Fig. 4.



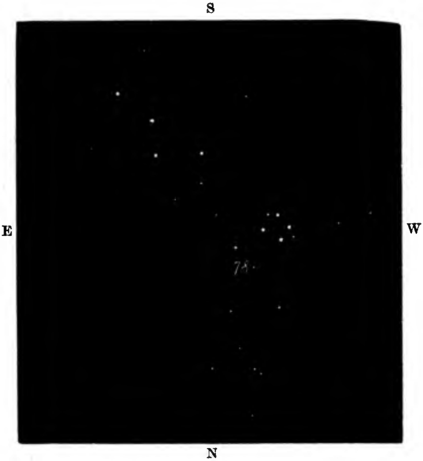
Nebula Orionis. (Herschel, 1824.)

Sir John likewise expresses an opinion as to the resolvability of the nebula, and describes its appearance in a very graphic way. He says: "I know not how to describe it better than by comparing it to a curdling liquid, or to a surface strewed over with flocks of wool, or to the breaking up of a mackerel sky when the clouds of which it consists begin to assume a cirrous appearance. . . . "It presents, however, "no appearance of being composed of small stars, and its aspect is altogether different from that of *resolvable nebulæ*. In the latter we fancy by glimpses that we see stars, or that, could we strain our sight a little more, we should see them. But the nebula suggests no idea of stars, but rather of something quite distinct from them."

In the beginning of 1834 Sir John Herschel went to the Cape of Good Hope for the purpose of completing a survey of the whole heavens, which had been commenced in England: he took with him his 20-foot reflector (aperture 18¼ inches), and devoted himself during his stay there to astronomical work. The nebula of Orion of course attracted much of his attention, and on account of its favorable situation for observation he was enabled to examine it to much better advantage than in England. In the "Astronomical Observations at the Cape of Good Hope," Herschel has given a figure of the nebula as he saw it (see Fig. 3), and has added an account of its appearance, a portion of which account we shall quote.

Fig. 5 is a representation of the small stars immediately in the vicinity of the trapezium as seen by Herschel.

Fig. 5.



Nebula Orionis. (Herschel, 1834.)

It is easily seen that the circumstances at the Cape of Good Hope were much more favorable than they had been in England: this is witnessed in the figures here given by the greater number of stars shown, and in the original drawing by the amount of detail in the features of the nebula itself. The nebulosity surrounding θ Orionis was traced by Herschel over half a square degree of space, and numerous points of doubt were settled. In his account Herschel states that he discovered the sixth star of the trapezium in 1832, and he expresses his surprise that Struve, who had examined the stars in this neighborhood frequently, should have overlooked it.

Da Vico, of the Roman College, had in 1839 declared that he had seen the stars *within* the trapezium (an assertion which has been repeated since by various observers, good and bad), and Herschel takes the opportunity to declare that not only had he seen no stars there, but that the absence of any trace of star or even of nebulosity was one of its most striking features. (Herschel's remarks in this regard are fully confirmed by the best observers.)

But, as we may see by a reference to Fig. 5, Herschel had discovered quite a number of small stars, some of them extremely faint and difficult, notably one marked 78 in the figure (No. 78 of Herschel's Catalogue).

Later researches on the stars in this group have added largely to their number, but hardly any have been found more faint than this star H. 78.

Bond, of Cambridge, and O. Struve, of Pulkova, with the fifteen-inch refractors of those observatories, both observed it and found it extremely difficult, and both of these observers supposed it to be variable in magnitude. It seems almost impossible that Herschel should have seen H. 78 and that he should *not* have seen others seen by both Bond and Struve, if the star was as faint in 1834 as it is in 1874; and the inference seems hard to avoid, that this very faint star was perceptibly brighter in 1834 than at present.

Herschel discusses the evidences of change in the nebula at some length, and, although his own drawings of 1824 and 1837 differ as much as any two drawings which we have, he is strongly of belief that these differences, although great, "are not more so than I am disposed to attribute to inexperience in such delineations," and to various other causes, such as the favorable situation of the nebula in the southern sky, etc. One part of the nebula he does regard as probably variable, and, to prove this, he compares his two drawings. It may be said that, so far as our knowledge now goes, this suspicion of Herschel's is not confirmed.

In 1852, Mr. Lassell, already famous as the discoverer of various satellites of the major planets, took his magnificent twenty-foot reflector to Valetta, to use it to good advantage in the serene atmosphere there. While his telescope was mounted at Valetta, Mr. Lassell made careful observations of the Orion nebula, and he even had a painting in oil made from his own drawings, and from the nebula itself, by an artist-friend. When we consider the immense difficulty of drawing even the *form* of so complex an object as this is at the telescope, from which the eye must be removed every moment to add a new line, or to verify one already drawn, and when we further consider what added pains must be taken in order to get an approach to accuracy of light and shade, we must admit that the attempt to represent not only form, and light and dark, but also color and tint, is almost a vain one. Accordingly, we find Mr. Lassell's drawing of the nebula itself to be strikingly different from Herschel's or Rosse's (made in 1867), but we ought not on that account assume any change in the nebula itself. Any one who has made such drawings will know what strong and direct evidence of change must be had to establish it as a fact.

Mr. Lassell's drawing (Fig. 6) exhibits the same characteristics as Herschel's in one respect. He has noted some very faint stars, particularly one, of which we will speak further, but he has omitted others much brighter (at least, brighter in 1874, and also brighter when mapped by Bond in 1865). We must attribute this to a desire to depict the form of the nebula itself, and a neglect of the stars in comparison; and yet this is difficult to do, since Lassell has given us a map of new stars which he found, some of which have never been seen by any observer since, and presumably do not exist, or have vanished. Lassell, again, finds no trace of resolvability in this nebula.

FIG. 6.

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NEBULA ORIONIS. (Lassell, 1852.)

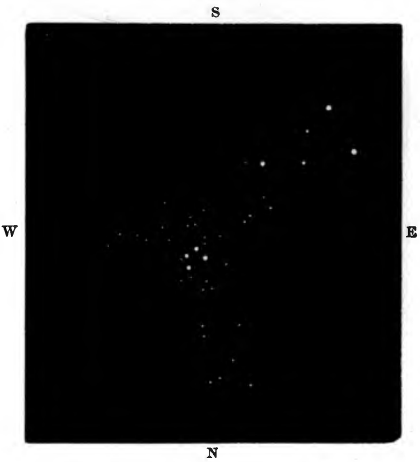
It will be noticed that Lassell has a large number of small stars above and to the left of the trapezium. These are put in the map by eye-estimates of their position, and it is somewhat difficult to identify them with Bond's stars in this place, but I have no doubt that all of them are real. Lassell's *b* and *g* have never been seen by any later observer, and probably they do not exist. *a'* of Lassell's map was not even noted by him as a new discovery, but it remained unseen even by the keen vision of Bond and Struve, until the mounting of the great Alvan Clark refractor (18½ inches aperture) in 1862, when Alvan Clark, Jr., found this star by the aid of that instrument.

His observation has been verified by the great Clark refractor, at Washington (26 inches aperture).

In 1848, Mr. W. C. Bond, Director of Harvard College Observatory, made, by the aid of the 15-inch refractor, a map and a drawing of the nebula and its contained stars. There was a large number of errors in this catalogue, and Bond's work was sharply criticised by O. Struve, whose "Memoir on the Nebula of Orion" appeared in 1862. Struve's work, which was a revision and an extension of the work of Liapanoff (done at Kazan with a 9-inch refractor), was executed very carefully with the 15-inch telescope of Pulkova; and some of his strictures on the elder Bond's work were so severe as to induce G. P. Bond, his son, then Director of Harvard College Observatory, to take up his father's work, to complete and amend it. This he has done in a most admirable monograph, which is a model of its kind. We have already spoken of his engraving of the nebula, and its excellence is only commensurate with the completeness of the whole of the memoir.

Fig. 7 represents the small stars in the now familiar ground near the trapezium.

FIG. 7.



NEBULA ORIONIS. (G. P. Bond, 1865.)

It will be seen how much fuller this map is than Lassell's, which contains more small stars probably than any of the preceding ones.

Lord Rosse's great reflecting telescope of 6-feet aperture was employed at various times, between 1848 and 1867, in making drawings of the Orion nebula; and we have, as the results of the work, two great engravings, upon which much care has been spent.

These certainly differ in many important points from the preceding drawings which were made by reflectors (and experience will show us that it is not easy, critically, to compare drawings made by reflectors and by refractors); but this is simply a proof that the drawings of different instruments are hardly comparable. Indeed, drawings by different observers, with the same instrument, and made at the same time, are often as different from each other as any of the previous drawings from Lord Rosse's.

The resolvability of the nebula is claimed by Lord Rosse, but the testimony of the spectroscope, as far as that goes, is against that inference, and the testimony of large telescopes, at least equal to Lord Rosse's in their defining power, is likewise unanimously contrary.

Any one, who will critically study the drawings named above, will, it is believed, arrive at the conclusion that no traces of resolvability have been fairly made out. Changes of form, although the evidence of the various drawings is seemingly in favor of such changes, are not probable, from a comparison of all the data. The drawing of Bond is confirmed, we believe, by Safford, of Chicago, by aid of the 18½-inch refractor, and by the great refractor of the Naval Observatory at Washington, so far as an examination has been made, and

Fig. 8.

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Nebula Orionis. (Rosse, 1860–'67.)

after a careful collation of all drawings; the only inference it seems possible now to draw is as to the enormous personal differences of the artists. It should be remembered that the difficulty of getting a correct drawing engraved correctly is itself immense, and not often to be overcome, especially if the engraver has not himself studied the nebula which he is to represent.

Fig. 8 is a part of Rosse's drawing made with the six-foot telescope.

It will be seen that the number of small stars above and west of the trapezium is very small, but a reference to the original drawing would show that the nebula was traced very far away from the central star: we see from these facts that the famous Rosse telescope is surpassed by several other telescopes in *definition*, but its enormous surface, when in good condition, is a great light-gatherer, and a faint nebulosity is distinguished in it more easily than in most other instruments—Lassell's reflector, for example.

Bond, however, has surpassed, by the aid of the 15-inch refractor at Cambridge, the work of Lord Rosse's assistants in every way, even in regard to the very points for which the reflector was best fitted. We must, however, attribute this, in no small degree, to the skill and assiduity of Bond himself.

We have thus traced the history of the nebula of Orion, as developed by the telescope alone, from its discovery to the present time. This has been done only imperfectly, on account of the impossibility of presenting complete engravings of the drawings made by the different observers, to whose work reference has been made. Several other astronomers of note have worked on this subject—notably Lamont and Secchi—but the results of their telescopic work are included in the preceding account.

The necessary conclusions as to the resolvability and change of the nebula have been indicated, as well as the strong probability that the nebula and the stars in the neighborhood are physically connected, which inference is mainly drawn from the recession of the nebula spoken of by Herschel.

The progress of telescopic research is well shown by the additions made year by year to our knowledge of this beautiful object, and we have no reason to be ashamed of it. The spectroscope has been busy on this nebula, as with others; but of its work it is not our purpose to speak. The desideratum in the study of these faint objects seems to be the extension of photography to their delineation. Until that is accomplished, we may rest content with such work as Bond and Struve have left us.[1]

[1] It is understood that a drawing of the Orion Nebula is soon to be published, unde the direction of Prof. Winlock, the present Director of Harvard College Observatory This is to be executed by Mr. Trouvelot, to whom we already owe many beautiful drawings of celestial objects, published under the auspices of the Harvard College Observatory.

THE GENESIS OF WOMAN.

By ELY VAN DE WARKER, M. D.

IN the construction of a piece of delicate mechanism there are two crises. Through some fault in its construction it may not permit movement in any part; and, each part being perfect, yet, through some defect in the arrangement, it may be capable of motion, but unable to fulfill the purpose for which it was designed. The first is an error of structure, the last an error of function.

If in the construction of the machine these sources of failure were avoided, it would perform its appointed office, until interrupted by an accident, or the natural wear of the parts entails both errors of structure and function.

At birth in the human animal sex is as distinct as at any after-period of life. Birth merely marks a stage of development, and not a change in design. Fœtal life to the perfection of the sexual design embraces simply a process of construction. This is the period in which the crises occur. By arrest of development, through imperfection in the structure of subsidiary parts, the perfection of function may never be reached. This would result from an error of structure. Structural perfection may be attained; but, through some defect in the mutual dependence of the parts, the perfection of sexual design may never be reached. This would result from functional error. The woman who has reached the stature and years which mark completion of structure, but in whom certain organs, vital to the attainment of sexual perfection, remain in an embryonic condition, or one who has reached anatomical perfection, but through defect of function may never gain that expression of sexual perfection called perfect ovulation, may be, in every other respect, physically a perfect woman, but has given a total defeat to the purpose for which she was designed. Both these errors are incidents in the genesis of woman. A fault of sexual function does not spring into existence the moment sexual life is to be crowned by ovulation. This imperfect function is a result, not a process. It antedates the commencement of ovarian life. It may be occult in the years of childhood, it may be antenatal, or even an error of ancestry. I believe it exists with the force of a law, that the conditions which result in ovarian irregularity are operative before and not during the establishment of that function. This office, like any other of the body, is exposed to the accidents of disease; but I think it may be proved that when irregularity of this function is the result of concurrent causes it is purely an accident—the exception which confirms the rule.

Young women become an object of parental or medical solicitude at a period when it will have but little influence on the perfection or imperfection of their sexual life. By the keenness of the vision directed to this period of woman's genesis, they are blinded to all the years of formative childhood. Perfect function is an expression for perfect organs. Women do not reach the inception of ovarian life with organs in an infantile condition. During the years of childhood structural evolution goes on, and ends in the climax of function. It naturally follows, that during the period of structural development are sown the seeds of ovarian ill-health. For instance: given, a child with no inherited taint, reared as she ought to be, mentally, bodily, and hygienically, and who escapes the accidents incident to growth, and some time, between the years of thirteen and eighteen, she becomes functionally perfect, without trouble and without hazard, be she at the boarding-school, at college, or at home in the whirl of fashion.

As this subject is having a practical bearing upon the usefulness and higher education of young women at what is commonly regarded the critical period of their development, I deem it in the interest of a more perfect understanding of the matter, that it be studied in the light of recent physiology. It is apparent from the above, that instead of confining the critical period of woman's development to the establishment of ovarian function, I believe that the true crisis is confined to the formative years of childhood.

In stating my idea of the genesis of woman sexually, it will be necessary for me to keep in view the usually accepted belief, and to apply reasonable objections, based upon admitted physiological data, to the value assigned to puberty. It is at this period, when young women are entering upon their higher education, that it is claimed they are physically and mentally disabled from pursuing the same studies, in the same manner, and in the same institutions, with young men; and that their time and study must be arranged solely with reference to ovarian function. This is the latest medical opinion upon this question. The answer to this comes from a class of society, from men and women engaged in teaching the sexes, either separately or together. The answer is a flat denial, and has almost a flavor of poetic justice. It is couching the lance in defense of woman against the grave charge of periodicity. It is a matter to be regretted that those who have answered this content themselves with facts which have simply a negative value. It is evident that if ever a generally-accepted opinion upon this question is to be reached, it is attainable only by giving a just value, physiologically and hygienically, to the puberic age.

The position of writers upon the diseases of women, on this subject, is unfortunate, and one badly calculated to conserve public health. They comparatively ignore the formative years of childhood, or if referred to at all it is so incidentally that the interest turns upon the year of puberty. Dr. E. J. Tilt, of London, traces the diseases of ovulation to ovaritis, acute, subacute, and chronic. In his chain of cause and effect he speaks of those only which lie at the very threshold of diseased action. Tracing back these morbid acts to their remote causes, he says a few words of those which we have all heard so much about—late hours and suppers, idle and luxurious habits, improper dress and exciting literature. I have no disposition to deny these conditions their just value in the cause of ovaritis. I acknowledge the importance of the diseases which he describes in the production of ovarian derangement. But, he speaks of the woman and ignores the child; the accidents of completion are all, and the accidents of formation nothing. There are causes of ovarian derangement other than those which are given by Dr. Tilt. Inflammation is not the only error of structure which may so result. There are conditions which must be assigned to the formative years of life. Relative excess or deficiency is one, and nervous action, radiating from the central or ganglionic systems, exerts a potent and unmeasured power for weal or woe upon ovarian periodicity. Dr. Tilt is not alone in assigning undue importance to the accidents of puberty. Dr. Meigs has had great influence upon the forming of opinion in this country, and his influence has been the more deeply felt from his having clothed with the graces of rhetoric some stern pathological facts. In describing the advent of puberty he has indulged in a sort of physiological antithesis. The child-life of woman is the material which is suddenly transformed into a being clothed in beauty, veiled in modesty, pulsating with charming passion and the divine consciousness of possible maternity. This is what the doctor says: "The earliest years of her life are occupied then in bringing her up to that point of perfect development of her alimentary, respiratory, innervative, and circulatory life, that may fit her for exerting the great reproductive force" ("Diseases of Women," p. 373); and "the transverse and antero-posterior diameters of the pelvis have suddenly and visibly increased" (p. 375); and "it seems as if the forces which had been employed to perfect the beautiful machine, by arranging and completing the quantitative synthesis of its organism, were now occupied, in a sort of paroxysmal intensity, with adorning it with all its graces and attractions, and setting upon it the seal of perfection" (p. 376); and, lastly, "this occurs between fourteen and fifteen years of age" (p. 372). This is certainly leaving a good many physiological facts unnoticed for the sake of dramatic unity. Leaving out the manner, the above is about the substance of what has been written by gynæcological writers upon this period of woman's life. Anatomical writers are also guilty of coming to hasty conclusions upon what ought to be regarded matters of fact rather than of opinion. Mr. Gray, in his "Anatomy," says, that "*about puberty* the pelvis in both sexes presents the general characters of the adult male pelvis, *but after* puberty it acquires the sexual characters peculiar to it in adult life" ("Anatomy, Descriptive and Surgical," p. 158).

In my first quotation, alimentation, respiration, innervation, and circulation, are spoken of, but no word of the development of sex, the very thing our author is writing about. Now, the normal evolutions of Nature, either physically or psychologically, are never paroxysmal. If the forces which direct development find expression in paroxysm, it constitutes disease and not health. It is almost impossible to conceive of a woman who is developed from a child in one year; and yet, this sudden transformation is generally regarded as a fact in the genesis of woman. In regard to the sudden increase of the pelvic diameters, I cannot but consider it as an "event viewed unequally," as the late Prof. Czermak said. I am not aware of the existence of any measurements of the pelves of children approaching puberic life which give the least color of evidence to this assertion. On the contrary, it is opposed to the common order of growth in plants and animals. The transverse and antero-posterior diameters of the cavity of the pelvis in the two sexes differ about one inch, roughly stated. If this difference is objected to as too great, there is still an admitted difference which would render such an increase of bone formation as a sudden development impossible. The opinion of Mr. Gray, that pelvic development is a post-puberic phenomenon, makes it necessary to explain some very absurd conclusions which legitimately follow. Such a condition would ascribe functions, which are the most perfect expressions for high structural development, to infantile organs. If there are those who still insist that Mr. Gray is right, they must admit the violation of a physiological law: that the organs within the pelvis have outgrown the capacity of the cavity containing them; that there exist adult organs in an infantile pelvis. Such a state of things in a healthy animal is impossible, if we accept the evidence of universal experience. The cavities of the cranium, the thorax, and the pelvis, have a steady and relatively equal development. In the accepted description of the sudden onset of ovarian life, and the equally rapid anatomical accommodation of the osseous and soft parts, mental changes are described as present which are as profound and important as those attending pelvic development. But it has never been thought necessary to describe any increase in cranial capacity to accommodate these objective mental phenomena. Even a new mental attribute is believed to be developed (Meigs), that of modesty, and it is therefore as reasonable to expect, to a limited extent, cranial as well as pelvic increase. Stated in this way—and it is a fair statement—it does not seem possible to accept Mr. Gray's opinion as an anatomical fact. Women do not necessarily cease to develop because of the establishment of the ovarian function. As a rule, women will increase in stature until the twenty-fifth year. It is an equable growth, a cementing, a binding together, and final completion. I regard this fact as evidence of the steady and gradual structural and functional evolution existent during the formative years of childhood, and prolonged into the child-bearing era. Were changes of structure really as rapid at this period, it would imply vital depression, just as we see it in plants and animals taking on rapid growth, and just as we see impaired mental and bodily energy follow sudden and excessive exercise of any organ in a member of the human family. Yet at puberty the opposite occurs. Women are never so hopeful, buoyant, and strong, as at the beginning of healthy ovulation.

Analogy furnishes strong arguments in favor of the early and gradual preparation of the system generally for the ovarian function. Mammary enlargement antedates functional activity by months in cases of gestation. Here is a comparatively simple act, that of glandular secretion, preceded by elaborate structural preparation. In the sexual cycle of organs the mammæ act a subordinate part; yet in this region, in the two sexes during childhood, the first sexual characteristics may be detected in the well-developed. This is an interesting and most significant fact, and one that renders it highly improbable that pelvic enlargement is postponed to the puberic age, and coincides with many other facts which show that sexual evolution is a simultaneous movement toward completion by all the organs involved.

The commencement of the ovarian function is not the only crisis through which woman has to pass. There are two dentitions, each of which is a critical period. It is, I think, safe to say that the diseases incident to dentition destroy more human lives three to one than the diseases of ovarian function. Dentition is a process preceded by elaborate anatomical preparation, and furnishes the strongest analogous proof of gradual and persistent sexual development. Teeth which appear at the fifth to the sixth months of life, are preceded by anatomical changes begun as early as the sixth week of fœtal life. Teeth which are to make their appearance at the fifth to the ninth years of life are in a preparatory state at the seventh month after birth; and teeth which make their eruption between the seventeenth and twenty-first years are in a recognizable state of growth at the sixth year of age. Here is a most elaborate preparation for function, a slow and ceaseless building up, with—in a state of health—no paroxysmal outbreak, either in the growth or completion of function. It is equally true that the organs within the pelvis which characterize sex can be traced to a fœtal origin, and, during the months of infancy and years of childhood, they exhibit the same process of structural evolution. Paroxysm in the process of dentition is a disease, and it is equally a morbid act in the development of sexual maturity. Ovulation does not induce a greater change in the system and habits than does dentition. This may appear at the first glance to be an unwarranted assertion. But observe the change in the life and habits of the little human animal at the eruption of the deciduous teeth. After subsisting upon a single article of diet it becomes omnivorous: from entire dependence upon others, it has reached a certain amount of independence, which entails a change in the mental character of the child. It instinctively exercises its new function of prehension, and is as prone to bite as a woman is to love.

And here let me recall what I said at the opening of this paper upon errors of structure. This process of dentition will illustrate it, and render its application to the diseases of ovarian function apparent. It is during the formative process of dentition that the function may be perverted, the shape and growth retarded. During this slow development it is at the mercy of faulty nutrition and hygiene. Perfect nutrition and ceaseless care are necessary to avert the dangers of dentition. The effort to ward off these disasters would be useless which confined itself to the completion of the act, to the neglect of the formative process. And yet this is the manner in which the sexual completion of woman is treated. How much we hear of the woman, and how little of the child!

Mental changes are described as taking place as suddenly as those of the body. There are of course some subjective mental impressions which may be traced to the new ovarian function—the sense of completion, and the new relation it establishes with others, and the consciousness that half a lifetime will be under the dominion of a strange periodicity, a mystery to herself. Aside from these there are no newly-developed mental attributes which may be traced to sex. Any thing new in mental vigor which may present itself at this period of life is more clearly explained by the general maturity of mind and body than by the action of a special function, and the state of remote organs.

It has been believed until recently that the removal of the ovaries, by operation or disease, would unsex the woman; that the features would become thin and masculine, the voice harsh, and even a beard develop. This is now known to be a wrong belief. It is true that the removal of these organs has been over-estimated; is it not possible that the commencement of their functional activity has been given undue importance in their reflex effect upon mind and body? This is answered by the fact that so gradual is the growth of mind, and the expanding of the intellectual limits, that the closest observer will not detect the dividing line between childhood and womanhood. Look back, if you will, at the young woman who has grown up under your daily notice, and point out the period of her life—be it one of months or a year—in which sex has become, objectively, a part of brain-fibre. For myself it is impossible to perceive the era of this change, so gradually are the various stages of development merged into each other.

A few words about the function itself concerning which so much is being said. The periodic presence is regarded as an expression of ovarian activity alone. This is in a great measure true; but it is not all the truth. Facts which have been coming to the light in the last few years show that forces not of ovarian origin are engaged in determining the function and its periodical character. Women from whom both ovaria have been removed have lived on with this function in full force, identical, as to quantity and time, to the function previous to the removal (Peaslee, "Ovarian Tumors," p. 527). Cases have occurred in which the ovaria have never passed out of the rudimentary state, and yet the general character of these women is decidedly feminine, "and never reminds us of viragos" (Klob, "Pathological Anatomy of the Female Pelvic Organs," p. 14). So far as external sexual traits are concerned, such a woman differs in no manner from one who is functionally perfect. The natural inference is, that forces, other than those which spring from the ovaria and their function, are capable of directing development, and that there is a certain amount of sex, that of the general configuration of the body especially, which develops independently of ovarian stimulus.

We may also gain a knowledge, inferentially, of the establishment of ovulation by observing the manner of cessation of this function. Its decline and extinction is a slow and gradual process. This period has a mean duration of nearly three years (Tilt, "Change of Life," p. 65). There are also anatomical changes, which, if taken into account, would greatly extend this time. The gradual decline of the ovarian function is a type of its equally gradual inception. It is a reasonable inference that, whatever takes time in throwing down, also requires time in the building up. So far as the importance of the change of life and the beginning of ovulation are concerned, the latter greatly exceeds the former—I am speaking of the two phenomena as physiological acts—and yet we see the former always attended by anatomical preparation, and by a functional activity so slowly diminished, that even the subject herself is unconscious of the crisis through which she is passing. I have already alluded to the fact that paroxysm, or rapidity in the establishment of a function, is an evidence of disease, and not the healthy way Nature has of doing this work.

In an article of this kind many facts which have a direct bearing upon this question cannot be mentioned in detail. Such a fact is the early vice of a peculiar nature to which very young children become addicted. The impulse to this is generally ascribed to emotions which result from ovarian stimulus; but, on the contrary, the tendency to vice exists long anterior to the development of this function. I can only state the fact that the presence of the passions antedates the appearance of ovulation by months and years; thus, the interest mutually excited in children of opposite sex is not confined to nubile years. In support of this I can appeal to the common experience of adults.

The conclusions at which I arrive are briefly these:

That sex, structurally and functionally, from infancy to puberty, is in a state of slow and progressive evolution.

That the time occupied in the establishment of ovulation is not the true crisis in the development of woman.

That undue value has been given to simple ovarian growth and function as a factor in the development of womanly mental and structural peculiarities.

That in a state of health the inception of the ovarian function is never paroxysmal, or sudden.

That perfect structural development is followed by perfect function, and that the reverse of this is true; and, lastly—

That early diseased ovulation is mainly the result of physical, moral, and hygienic faults of the true crisis of woman—that of formative childhood—rather than of the period of puberty.

With these facts before us, is it not legitimate to assume that the puberic period in woman's life has been over-estimated in its direct influence upon her health at that and subsequent periods? Instead of curtailing her opportunities for work and study, by throwing around her restraints, and, as it were, creating a disability out of a natural function, transfer the attention and anxiety now lavished upon her, to a period when all that makes woman in the best and noblest sense is in a process of elaboration; for it is during this time of rapid structural change that the future good or bad health of the woman is determined. Let healthy ovulation be the natural outcome of a healthy childhood, and the function will obey its law of periodicity year by year, and all this time the young woman is as able to sustain uninterrupted physical and intellectual work as the young man. I do not wish to be understood as saying that at puberty, or at any other period of woman's life, the laws of health may be violated with impunity, but that a law of health is no more binding upon the young woman than upon the young man; that really there is no such thing as one law for women, and another for men. But the law of the woman is not the law of the child. The woman must follow those laws of health which keep her healthy; the child must be trained to obey those which will insure health in the woman. If I am right in tracing ovarian functional derangement mainly to the structural crisis, it is evident that the child must be an object of careful attention. It is not my purpose to mention the causes which will vitiate the development of the child. I desire to direct attention to this period as one full of danger to the future woman. Lest I be accused of ascribing too many of the disasters to which the functional health of women is liable to the period of childhood, I will say that women, and all the functions peculiar to their sex, are liable to the accidents of disease at any time; but, if we accept the evidence of the intelligent people who have the opportunity of observing large numbers of young women in schools and colleges, the early period of sexual function is not so liable to disease as when women are called upon to perform some of the higher duties of their being later in life. Neither is it my object to prejudice in any way the discussion of the co-education of the sexes. I think society is not prepared to discuss that question now. It is being worked out in the best possible manner, that of actual experiment. But, my aim has been to fix, if possible, the actual value of the puberic age of woman as a crisis, so that there may be no fictitious bar to her progress to either a higher education, or to her training for any of the skilled labors suited to her strength.

THE HUMMING-BIRDS.

By JAMES H. PARTRIDGE.

THE discovery of America opened up to the civilized world many new objects of interest in the animal, vegetable, and mineral kingdoms. Not the least in interest was the discovery of an extensive group of birds, consisting of several hundred species, whose diminutive size, quickness of motion, boldness of demeanor, elegance of form, and exquisite beauty of plumage, attracted the attention and secured the admiration of every lover of Nature.

The larger portion of these birds live in the West Indies and the tropical regions of America. Some occupy only a small island or district; others, a narrow belt on the side of a mountain: most do not extend their limits beyond a few degrees of latitude, while a few are migratory, and spend the summer in the temperate zone, but return to the tropical regions for the winter. Their food consists of honey and insects; and, consequently, they must live where flowers grow and insects abound. The Indians gave to these interesting little creatures fanciful names that expressed the idea of sunbeams, sun-angels, sun-gems, tresses of the day-star, murmuring-birds, and the like. And naturalists have given to them names equally fanciful, expressing the same or similar ideas, such as brilliant birds, light-bearers, sun-seekers, flower-kissers, honey-suckers, living meteors, and many others of similar meaning. They derive their common name from the buzzing or humming sound which they make with their wings. These vibrate so quickly as to be visible only as a semicircular film on each side of the body. The sound made by different species varies with the velocity of their wings. That made by the vervain humming-bird resembles the sound of a large bee; while that made by the polytmus resembles the sound of a swiftly-revolving wheel.

One of the peculiarities which first strikes a stranger, upon seeing one of these brilliant breathing gems, is the immense power of wing, shown by the quickness of his flight, also by the ease with which he balances himself in the air, whether, foraging unmolested, he is feeding at the flowers, or, attracted by curiosity, he is surveying one's person. He comes so suddenly as to give no warning to the eye; we hear a buzz, see the bird near us stationary, his form distinct, and when he leaves, so quick and sudden is his flight, that the eye can scarcely trace his pathway. The muscles of his wings are more powerful and active, in proportion to his size, than those of any other bird, and the wings are very long and sharp. For this reason he can easily hover, apparently motionless, for any length of time, before a flower whose honey he wishes to obtain. He thus sips the nectar of one flower after another for hours in succession, without showing any signs of weariness, or disturbing in the least the most delicate blossom.

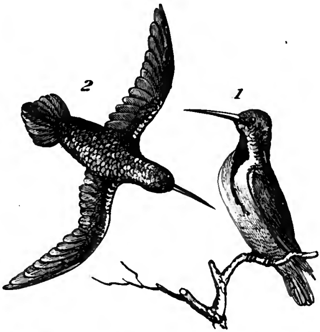
Fig. 1.

Ruby-throated Humming-bird (*Trochilus colubris*), common in the United States.

If any one wishes to observe these birds and their habits, let him, on a fine, pleasant morning, visit a cluster of gooseberry bushes when in bloom, of whose honey they are exceedingly fond, and he will probably find one or more of them quietly searching the flowers for food. If disturbed, he will frequently rise to a considerable height in an oblique direction, then dart down, almost with the velocity of a bullet, past the place of annoyance, and rise on the opposite side to an equal height; then return by reversing his course, and so repeat these sweeping movements, till he sufficiently expresses his disapprobation, drives away his adversary, or retires in disgust.

If two birds foraging come together, they usually fight; one drives the other away, and then goes on feeding as if nothing had happened. Mr. Gosse says: "If two vervain humming-birds are about the moringa-tree, one will fly off and suspend himself in the air a few yards distant, the other presently shoots off to him; and then, without touching each other, they mount upward with strong, rushing wings, perhaps for 500 feet. They then separate, and each shoots diagonally toward the ground, like a ball from a rifle, and, wheeling round, comes up to the blossoms again, and sucks, as if it had not moved away at all. The figure of the smaller humming-birds on the wing, their rapidity, their arrowy course, and their whole manner of flight, are entirely those of an insect: and one, who has watched the flight of a large beetle, or bee, will have a very good idea of one of these tropic gems, painted against the sky." Again he says: "I once witnessed a combat between two mango humming-birds, which was prosecuted with much pertinacity, and protracted to an unusual length. They chased each other through the labyrinth of twigs and flowers till, an opportunity occurring, the one would dart with fury upon the other, and then, with a loud rustling of their wings, they would twirl together round and round, until they nearly came to earth. At length an encounter took place pretty close to me, and I perceived that the beak of the one grasped the beak of the other, and, thus fastened, both whirled round and round in their perpendicular descent, till, when very near the ground, they separated; and the one chased the other for about a hundred yards, and then returned in triumph to the tree.

FIG. 2.



MANGO HUMMING-BIRD (*Lampornis mango*).—1. Male; 2. Female.

Sometimes they would suspend hostilities to suck a few blossoms, but mutual proximity was sure to bring them on again, with the same result. In their tortuous and rapid evolutions, the light from their ruby necks would now and then flash in the sun with gem-like radiance. The war lasted fully an hour, and then I was called away from the post of observation."

When these birds have nests, they defend them with great energy. They will attack and drive away any bird, however large, that disturbs them, or encroaches upon their territories. Wood says: "It has even been seen to attack the royal eagle itself, and to perch itself upon the head of its gigantic enemy, pecking away with hearty goodwill, and scattering the eagle's feathers in a stream, as the affrighted bird dashed screaming through the air, vainly attempting to rid itself of its puny foe." If a person comes near their nest, they will frequently hover very near, and scrutinize him with great deliberation and coolness. We learn from Humboldt, that, "according to the religious belief of the Mexicans, Torgamiqui, the spouse of the god of war, conducted the souls of those warriors who had died in the defense of the gods into the mansions of the sun, and there transformed them into humming-birds—an idea exquisitely spiritual, but perhaps only to be appreciated by those who have seen these birds gleaming like meteors, or shooting-stars, in their native regions."

All these birds are very small. The vervain humming-bird, of Jamaica, is one of the minutest of those at present known. Its body is less than an inch and a half long; its tail, less than an inch; and its total length less than three inches. Most are a little larger, and have longer tails. The largest bird in the family is the gigantic humming-bird of Chili, well proportioned, and nearly eight inches in length.

More than three hundred different species of humming-birds, or *Trochilidæ*, as the family is called, have been minutely described, and specimens carefully prepared and preserved. Many more species are supposed to exist in Mexico, and in the wilds of Central and South America. The family is divided, by Wood, into twenty-eight genera. While the earlier writers made a less number of divisions, some of the later European naturalists have made a much greater number: in one instance, no less than seventy-six genera and sub-genera. The extent of the family will be apparent when we consider that "the total number of the birds of Europe, of every order or group, amounts to no more than 503 species," while there are probably between 400 and 500 species of humming-birds that are included in this one family.[1]

Their bills are all very slender and sharp. Most of them are long; some are straight; many are curved downward; and a few are curved upward. They all appear to be adapted to the kind of flowers from which the birds obtain their food. Their tongue is a slender sucking-tube, and capable of being thrust out a long distance. It appears as though composed of two minute muscular tubes, lined within by two partial tubes of a substance resembling parchment, laid side by side, and joined together for about half of their length, but separate toward the tip, near which each partial tube becomes less curved, and apparently widened, then tapers to a point, the upper edge being irregularly notched or slit, the barbs pointing backward. The tongue is constantly moistened by a glutinous saliva, by means of which it is

[1] On the upper floor of the old Arsenal, in Central Park, New York City, at Sixty-fourth Street, there is a collection of several hundred prepared specimens of humming-birds, illustrating the great number and variety of species, and the extreme brilliancy and beauty of their plumage. This collection furnishes an opportunity, to any one who has the taste and leisure, to study this minute but interesting portion of natural history.

enabled to seize and hold insects. Says Martin: "It is by a pumping or sucking action, as we have every reason to believe, that nectar or fluids are absorbed by the tubular tongue of these birds. In no other vertebrate animals, as far as we know, is the tongue constructed as a tubular sucking-pump: so far, the humming-birds stand alone; and this circumstance in itself, considering it with reference to organic structure, might be adduced as a reason for regarding these birds as a distinct order."

Mr. Thomas Belt, author of "The Naturalist in Nicaragua," indicates another function performed by the curious cleft tongue of the humming-bird, viz., the capture of insects. As we have seen, this organ is, for one-half its length, made up of a substance like rather stiff parchment, or horn, and split in two. When at rest, the two

Fig. 3.

Tongue of Humming-bird, with Blades a little opened.

halves are laid flat against each other, but they can be separated at the will of the bird, and form a pair of forceps, admirably adapted for picking out minute insects from among the stamens of flowers.

We may admire the elegance of form and the quickness of motion of these birds, but the dazzling splendor of their plumage, resembling that of burnished metal or polished gems, changing with every change of position, has a charm for the dullest observer, and a fascination for the more sensitive. The wonderful change in color that takes place, according to the position of the light, from brilliant green, through the brightest golden tints, to intense velvety-black, or from black to emerald, or ruby, or crimson, or flame-color, reminds one of fairy-land, or the tales of the genii. Where a metallic lustre prevails, the plumage is always composed of feathers so shaped as to appear to have the form of scales. The birds vary in respect to the parts that have these feathers. While most have them on the throat, many have them on the breast and head; others have them also on the back; some have them on the wing-coverts or tail; and a few have them on nearly all parts, except the long wing-feathers, which are generally of a purplish-brown. It may here be asked, What causes the gorgeous metallic lustre of their plumage, and the rich, changing tints of the various colors, representing every hue of the rainbow, purple, amethyst, fiery crimson, brilliant ruby, radiant topaz, emerald green, resplendent blue, and glossy violet, which, in certain lights, often gleam with a refulgence that almost dazzles the eye? They have been attributed to various causes; but it appears to be the condition of the surface of the feathers that produces the iridescence. The surface is striated, or has minute furrows, like the nacre, or mother-of-pearl of the *Haliotis*, and other sea-shells, which decompose the light—absorbing part, and reflecting part; and the color of the reflected light depends upon the angle of the incident ray to the surface, and varies as the angle varies. In one direction of the incident ray, the light will be wholly absorbed, and, none being reflected, the surface will appear intensely black. It will readily be perceived that every movement of the bird produces more or less a change of color. Even the heaving of the breast, in breathing, sometimes produces perceptible changes.

The nests of humming-birds are curiously, skillfully, and quickly made. Most of them are formed of the down of the gigantic silk-cotton tree, or other vegetable fibres, worked into a sort of wadding or felt, and covered on the outside with particles of lichen, moss, webs of spiders, etc., the saliva of the bird being used to assist in holding the parts together. They are generally cup-shaped, or conical. Martin says: "In position, these nests are as different as imagination can conceive. Some are attached to the fork of a branch; others are bound to a waving twig enshrouded by foliage; others are pendent, attached to the extremity of the leaves of palms, flags, and other plants, overhanging water; others, again, build on rocks, hanging their nests by filaments to the sides of bold precipices; others hang their nests to the extremity of slender, pendent tendrils. Their eggs are two in number, white, but often, from their transparency, they display the color of the yolk, the shell appearing as if tinged with a blush of orange-red or pink. The eggs are a long oval, measuring, on the average, from three-eighths to one-half of an inch in length." Captain Lyon, writing from Gongo Soco, Brazil, says: "It may interest you to have an account of some young humming-birds, whose hatching and education I studiously attended, as the nest was made in a little orange-bush, by the side of a frequented walk, in my garden. It was composed of the silky down of a plant, and covered with small, flat pieces of yellow lichen. The first egg was laid January 26th, the second on the 28th, and two little creatures, like bees, made their appearance on the morning of February 14th. The old bird sat very close during the continuance of the heavy rain for several days and nights. The young remained blind until February 28th, and flew on the morning of March 7th, without previous practice, as strong and swiftly as the mother, taking their first start from the nest to a tree about twenty yards distant." The intense activity of humming-birds makes it necessary for them to have food containing nitrogen, which they get by feeding on insects. Honey furnishes proper food, or fuel, for the lungs, but it alone cannot form muscle, or give strength. They resemble the swifts in their powers of flight; the woodpeckers, in their means for darting out the tongue; and the sunbirds, in the metallic lustre of their plumage.

The ruby and topaz, or ruby-crested, humming-bird (*Chrysolampis moschitus*, Boié) derives its common name "from the color of its head and throat, the former being of a deep ruby tint, and the latter of a resplendent topaz." Chrysolampis, or gold-gleaming, is also very expressive of its appearance. On the head of the male bird, the feathers are elongated, and form a short, rounded crest, which can be raised or lowered at pleasure. The crest and upper part of the head appear of the most brilliant ruby-red, of a bright coppery lustre, or of a deep, sombre reddish-brown, according to the direction of the light and the observer. The throat and breast appear of the most brilliant topaz-

FIG. 4.

NEST OF RUBY AND TOPAZ HUMMING-BIRD.

yellow, of a clear golden-green, or of a sombre greenish-brown, under similar circumstances. Jardine says: "It is impossible to convey by words the idea of these tints; and, having mentioned those substances to which they approach nearest, imagination must be left to conceive the rest." The upper parts of the body are velvety bronze-brown, the tail-coverts having a greenish tinge, and the wings are purple-brown. The broad and expansive tail is of a "rich chestnut-red, tipped with black, and the abdomen is of a dark olive-brown. The female has none of the ruby patches on the head, but retains a little of the topaz on the throat."

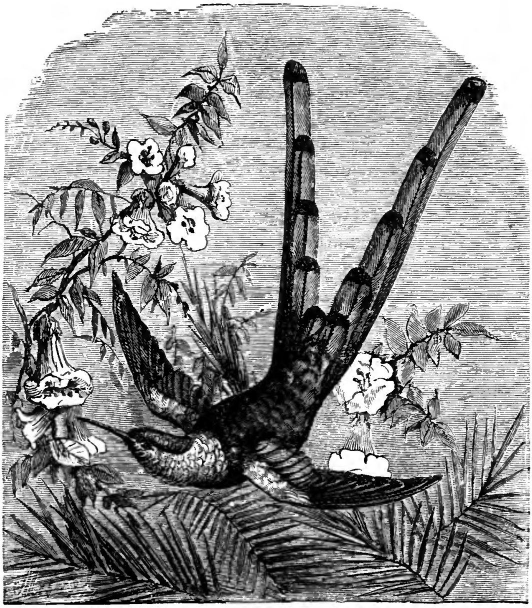
This species lives in the West Indies, and in various parts of South America. "It is in great request for the dealers, and thousands are killed annually. No species is so common as this in ornamental cases of humming-birds." Humming-birds are not only used for cabinet-specimens, but for various purposes of embellishment. The feathers are used to make flowers, pictures, and other ornaments. The birds are killed in various ways. Some are shot; but they are frequently so injured by this method as to be of little value. By the use of the *sarbacane*, or shooting-tube, they can be stunned and taken without much injury. They are sometimes caught in nets uninjured; and occasionally they are taken by putting bird-lime, or other glutinous substance, in flowers which they habitually visit.

The nest of this species is formed almost entirely of cotton or fine grass, and is thick, compact, and warm, the inside being about an inch in diameter, and the same in depth. It is frequently attached to a leaf, put on the small branches of a rush, or built on the twig of a small bush. Mr. Kirk, residing in the island of Tobago, says: "The ruby-crested humming-birds make their appearance here on the 1st of February. They begin to make their nests about the 10th. I now know (March 1st) of several containing two eggs each; and watched a bird building one yesterday for nearly an hour. Her manner of construction was very ingenious: bringing a pile of small grass or lichen, she commenced upon a small twig about a quarter of an inch in diameter, immediately below a large leaf, which entirely covers and conceals the nest from above, the height from the ground being about three feet. After the nest had received two or three of these grasses, she set herself in the centre, and, putting her long, slender beak over the outer edge, seemed to use it and her throat much in the same way as a mason does his trowel, for the purpose of smoothing, rubbing to and fro, and sweeping quite around. Each visit to the nest seemed to occupy only a couple of seconds, and her absence from it not more than two minutes. A few hours after I saw the nest, which had all the appearance of a finished one."

The sappho comet, or bar-tailed humming-bird (*Cometes sparganurus*, Gould), is remarkable for the development and splendid color of the tail of the male bird. The feathers are broad and truncate, and the outer pair five or six inches long, the others decreasing rapidly toward the inner ones. They are of a brilliant reddish orange, with a metallic lustre of the greatest clearness, assuming a greater tinge of red or yellow, according to the direction of the light. The tail is darker at the base and of a lighter or more fiery red toward the extremity. The tip of each feather has a broad black bar, and when the tail is closed these tips appear as five black bars or bands. The upper parts of the head, neck, and body, are of a golden green; the rump, of a fine madder-red without lustre; the sides of the face and neck are bronzed; wings, purple-brown; the throat and breast are of a bright emerald-green, with very brilliant metallic lustre; the abdomen, darker green. The female is smaller than the male, and has a shorter tail, and less brilliant color.

This species is a native of Bolivia, but spends the winter in Eastern Peru. It migrates southward to Bolivia in September or October, the spring of their year, raises its young, and, after spending the summer, returns northward with them in March or April, their autumn, to Eastern Peru. It is a remarkably familiar bird, for it not only feeds

Fig. 5.



Sappho Comet.

upon the flowers of the forest-trees, but visits the orchards when in bloom, the cottage shrubbery, the gardens, and the cultivated fields of maize, pulse, and other leguminous plants. It obtains an abundant supply of insect-food from the rich flowers of the cactus family. Mr. Bonelli says: "The difficulty of shooting these birds is inconceivably great, from the extraordinary turns and evolutions they make when on the wing; at one instant darting headlong into a flower; at the next, describing a circle in the air with such rapidity that the eye, unable to follow the movement, loses sight of it, until it again returns to the flower which at first attracted its attention."

The ruby-throated, or northern, humming-bird (*Trochilus colubris*, Linnæus) is so called, says Wood, "on account of the glowing, metallic feathers that blaze with ruby lustre upon its throat, and gleam in the sunshine like plumes of living fire. The general color of its upper surface and the two central tail-feathers is light, shining green, glazed with gold. The under parts of the body are grayish-white intermingled with green; and the throat is of the most gorgeous ruby carmine" tint, which changes, with the change of light, to a fiery crimson, to a burning orange, or to the deepest velvety black. The wings and eight tail-feathers are purplish-brown. The throat of the female is white.

The ruby-throats arrive in Louisiana and Florida in the first part of March, and, gradually proceeding north as the weather grows warm, arrive in Pennsylvania in the latter part of April, and in New York and Canada in May. They generally build their nests two or three weeks after their arrival. They usually place them a few feet from the ground, on an almost level branch of some tree, as the white-oak or pear tree, and extend the bottom of the nest round the limb so as to inclose it and appear as a mere mossy knot, or natural enlargement. Audubon says: "The nest of this humming-bird is of the most delicate nature, the external parts being formed of a light-gray lichen, found on the branches of trees or on decayed fence-rails, and so neatly arranged round the whole nest, as well as to some distance from the spot where it is attached, as to seem part of the branch or stem itself. These little pieces of lichen are glued together by the saliva of the bird. The next coating consists of cottony substances, and the innermost, of silky fibres, obtained from various plants, all extremely delicate and soft. On this comfortable bed, as if in contradiction to the axiom that the smaller the species the greater the number of eggs, the female lays only two, which are pure white, and almost oval. Ten days are required for their hatching; and the birds raise two broods in a season. In one week the young are ready to fly; but are fed by the parents for nearly another week. They receive their food directly from the bill of their parents, who disgorge it in the manner of canaries and pigeons." They probably join the young of other broods, and migrate without the old ones. They no not receive their full brilliancy till the next spring. When caught in a gauze net they easily die, or simulate death.

The ruby-throat has sometimes been tamed. Mr. Webber, in his "Wild Scenes and Song Birds," says, after several unsuccessful attempts, at last "I succeeded in securing an uninjured captive, which, to my inexpressible delight, proved to be one of the ruby-throated species, the most splendid and diminutive, that comes north of Florida. It immediately suggested itself to me that a mixture of two parts of loaf-sugar, with one of fine honey, in ten of water, would make about the nearest approach to the nectar of flowers. While my sister ran to prepare it, I gradually opened my hand to look at my prisoner, and saw to my no little amusement as well as suspicion, that it was actually 'playing 'possum'—feigning to be dead, most skillfully. It lay on my open palm motionless for some minutes, during which I watched it in breathless curiosity. I saw it gradually open its bright little eyes to peep whether the way was clear, and then close them slowly as it caught my eye upon it. But when the manufactured nectar came, and a drop was touched upon the point of its bill, it came to life very suddenly, and, in a moment, was on its legs, drinking with eager gusto of the refreshing draught, from a silver teaspoon. When sated it refused to take any more, and sat perched with the coolest self-composure on my finger, and plumed itself quite as artistically as if on its favorite spray. I was enchanted with the bold, innocent confidence with which it turned up its keen black eyes to survey us, as much as to say, 'Well, good folks! who are you?' By the next day it would come from any part of either room, alight upon the side of a white China cup containing the mixture, and drink eagerly, with its long bill thrust into the very base. It would alight on my fingers, and seem to talk with us endearingly in its soft chirps." Mr. Webber afterward succeeded in taming several of the same species. He gave them their liberty occasionally, and they returned regularly. At the time for migration they left for the winter; but, the next spring, they sought their old quarters, and accepted the delicious nectar kindly provided for them, and by degrees brought their mates. "He frequently observed, while watching for their nest, that the ruby-throats, after leaving their station, shot suddenly and perpendicularly in the air until they became invisible. At last, he had the great satisfaction of seeing the female bird fall, like a fiery aërolite from the sky, upon the spot where she had built her nest." From this he inferred that, instinctively for concealment, such was their usual practice.

The ruby-throats generally prefer tubular flowers, such as those of the thorn-apple, trumpet-flower, honeysuckle, etc., though, in case of need, they appear not to reject any one that will furnish them food. But there is nothing that will attract them so effectually, under all circumstances, as a large cluster of gooseberry-bushes in full bloom. And any one having such a cluster, and a little leisure, can at the proper season have the opportunity of observing their beauty and studying their habits. And this is very desirable and satisfactory to an inquisitive mind; for words, engravings, paintings, and even cabinet specimens, fail to give a true and full impression of the vivid and changeful tints, like the flashings of the ruby, the topaz, and the emerald, that proceed from these exquisitely beautiful winged gems.

THE DEVELOPMENT OF PSYCHOLOGY.

THE progress of Psychology has been determined by agencies which may, with much precision, be discriminated as two sets of conflicting yet coöperating forces—those maintaining equilibrium, and those producing motion. This language would be justly condemned as mechanical if it in any degree presupposed the vulgar notion of force, as acting on visible masses of matter and causing sensible motion. But since vital, mental, and even social phenomena, as well as the oscillations of molecules and the ethereal undulations, are now alike interpreted in terms of mechanism, we may reasonably claim that the phraseology shall receive the greatest latitude of interpretation consistent with the admission of no mechanical assumptions. If, with more propriety, it be censured as scholastic, as raising mere observed uniformities into self-acting entities, it may be replied that the term force is scholastic only when used scholastically, that it has a true and unmistakable meaning as a generalization simply, and that progress of all kinds can be best described in the language of the science which has clothed the laws of the action of force with the greatest possible precision and certainty. Under these reservations, we use no mere metaphor in describing the development of Psychology as due to two sets of forces, which may be styled kinetical and statical respectively, according as their function has been to produce external change or to effect those internal readjustments which previous changes had rendered necessary.

The statical factor in psychological history is Theology. The mother of all the sciences, it gives birth to Psychology first of the sciences of mind; all the great problems, the discussion of which carries the science through its subsequent revolutions, are raised by it; and we may find that its perpetual function, of which it can never be discharged, is to recall attention from temporary physical solutions to the insoluble problems themselves.

The kinetical factor is constituted by the whole series of the physical sciences, though at any particular epoch it takes the character of the dominant science. Each stage in the development of Psychology corresponds to some stage in the evolution of the natural sciences; by each such transition has each psychological development been caused and conditioned; and the progress of Psychology in fundamental truth, and its more complete emancipation from Theology and Metaphysics, are to be measured by the degree in which physical methods, physical conceptions, and even physical metaphors, have been applied to the interpretation of the facts of mind.

The primitive savage, looking out upon the world, finds no God; gazing inward upon himself, perceives no Soul; and thinking of the origin of things, can conceive no Creation. His gods are parts of the world, not makers of it; such soul as he ascribes to himself is merely his own double, which perishes with him or soon after, or he has several souls; and the earth, as he sees it, was not made but hooked up from the bottom of the original sea.[1] To the undiscriminating mind of the savage the Cosmos is accordingly all but homogeneous, with just the beginnings of "differentiation," and God, Man, and Nature, have yet to acquire an independent existence. There is still, therefore, no room for Psychology.

Plato gets several stages further than this. With him the Cosmos is a divine immortal being or animal, composed of a spherical rotatory body and a rational soul. The gods dwell in the peripheral or celestial regions, and men and the animals inhabit the lower or more central regions. The cranium of man is a little Cosmos, with an immortal rational soul, composed of the same materials as the cosmical soul, and moving with the like rotations. Within the body on which this cranium is placed are two inferior and mortal souls; one, the seat of courage, etc., in the chest; the other, the seat of appetite in the abdomen; both of them being rooted in the spinal marrow, which is continuous with the brain, and is the medium of the unity or communication of the three souls.[2] In this semi-barbaric Cosmology we may note that the gods are still mixed up with the Cosmos, though the beginnings of separation are shown by their lodgment in a specific place; that they still want unity; and that there is yet no conception of nature. But we are here more concerned to observe that though the human soul is never actually separated from the body, i. e., is not yet detached from the Cosmos, and though it has the corporeal properties of extension and motion, body and soul, microcosmical and macrocosmical, are set sharply over against one another, and the first decided step toward their absolute separation is taken.

The metaphysical advance of Aristotle is immense. The three Platonic souls are merged in one, though the remains of the old idea are visible in the different attributes and distinct origin of the Nutritive, the Nutritive-sentient, and the Noëtic principles. But the Nutrient principle is the indispensable basis, without which neither of the others can exist, and the next higher principle, the Sentient, implies and contains the lower. In the investigations of the properties of these we have the beginnings of Psychology. It is not yet indeed an independent science, for the soul is still imperfectly extricated from the Cosmos—the Noëtic principle having its proper abode in the concave of heaven, and being only temporarily localized in the human body. The soul is still, as regards man, mortal, though as regards the Cosmos it is imperishable.[3]

[1] Lubbock, "Origin of Civilization," pp. 245–250.

[2] Grote, "Psychology of Aristotle," in Bain's "Senses and Intellect," pp. 612–614.

[3] Ibid.

Between Aristotle and the thirteenth century the metaphysical evolution was slow, and the stages few and short. The idea of God as an independent existence received its first elaboration in the controversies of the Greek Fathers about the Trinity; was perhaps first sharply discriminated by Anselm; and was raised to the highest pitch of sublimation by the Deistic debates of the seventeenth century, with which the "return of the curve" begins. The idea of Nature, isolated alike from God and Man, emerged from the Italian pantheistic schools of the fifteenth century, to be decisively established with the foundation of Natural Philosophy. The idea of the Soul, with which we are here concerned, was the first of the three elements latent in the primitive homogeneous Cosmos to be completely "differentiated." Whether there was any intrinsic necessity in its earlier evolution; whether it was earlier developed because humanity itself and not merely the metaphysicians contributed to it;[1] or whether it was solely the result of the working of the statical factor in the history of Psychology—the necessities of Theology; its first clear, though not complete, extrication may plausibly be placed as high up as the thirteenth century. As with the other two constitutive ideas, its emergence was the issue of a prolonged debate. No mediæval controversy made more noise while it lasted than the fierce war between the Averroists and the Schoolmen *de unitate intellectus* (concerning the oneness of the intellect). Averroës himself, the Arabian Hobbes, had been dead for half a century, but his doctrines had excited an extraordinary ferment among the younger and more speculative minds, and they reached the climax of their popularity just when the Scholastic Philosophy attained in Thomas Aquinas the culminating point in its history. East and West, Semitism and Aryanism, pantheistic absorption and political individualism, in the guise of Aristotle Arabized and Aristotle Christianized, met in final conflict, and the overthrow was, for the time at least, decisive. The theory of Averroës about the Soul was an imposing and picturesque development of the cosmical Psychology of Aristotle. The Nous of Aristotle was only temporarily localized in the body, and, after the death of the matter which it *informed*, returned to the grand region of Form, the Celestial Body. Averroës first severed the Nous from the Cosmos, unified it in humanity which it actualized, and made it eternal there. But it was only the common possession of the race through all time, and not particular to the individual; there were no souls, but only a single vast Soul, of which each generation was the perishable embodiment, but itself imperishable. Simple-minded, undoubting Thomas, with his eternal "Aristoteles dicit," "Aristoteles respondet," "Aristoteles habet" (Aristotle says, replies, has this), as if the question were to be thus settled, had no difficulty in showing that this was not, what the Averroists felt obliged to maintain, the doctrine of Aristotle.[2] But it was an advance upon that doctrine

[1] *See* Michelet, "Histoire de France," book iv., ch. vi.

[2] "De Unitate Intellectûs," *passim*.

without which Aquinas's own unquestionable advance upon Averroës might never, or not so soon, have been made. While, however, Thomas successfully asserted against the Arabians the individuality of the soul,[1] and against the older Aristotelians its substantial unity,[2] there was still another step to be taken before its independence on all sides could be regarded as established, and the ground cleared for the science of Psychology. That step was taken by Descartes, in whom mankind may be said to have come to a consciousness of itself. His "*Cogito, ergo sum*" (I think; therefore I am), was not logical, but genetic. The force of the *ergo* (therefore), as Ferrier long ago pointed out, lay in the fact that the existence of Descartes as a self-conscious being—*sum* (I am)—was resultant upon the process described by the word *cogito* (I think)—the turning of the light of self-consciousness upon the thinking principle itself. We have but extended Ferrier's interpretation from the development of self-consciousness in the individual to the metaphysical evolution of the *ego* (me) in human history. Not till this had been accomplished, and the Mind made a separate individual existence as against God and Nature, was any independent science of Psychology possible. Observations and reasonings on Man, as on the Deity and the Creation, formed part of the "undifferentiated" mass of speculation on things in general called Cosmology or Theology, and latterly, in a mutilated condition, Metaphysics. Any mediæval cyclopædia will furnish illustrations.

Thomas Aquinas, a faithful representative of the frightened orthodoxy of the Middle Ages, unsuspectingly follows the course of Creation, well known to have happened as laid down in the Book of Genesis. After forty-four *Quæstiones* (Questions) on God (under whom he discusses the nature of ideas and the metaphysics of truth) and the Trinity, and thirty on the Angels, the Devils (here arises, naturally, a discussion on the nature of evil), and the seven days of creation and rest, Thomas arrives, by an obvious logical sequence, at the psychology of man. One *quæstio* (question) settles the essence of the soul, another the union of soul and body; three exhaust the powers of mind in general and special, and the intellectual powers; four expound appetite, sensuality, the will, and free-will; and, having in seven more disposed of the remaining faculties of the soul, including such small subjects as "the mode and order of intellection," Thomas is prepared to deal with the production of man's body, and then evidently with the production of woman's body.[3] A witty journalist is reported to have said of an eminent living thinker, "God made the world in six days, and So-and-so wrote it down on the seventh;" but the entire Synthetic Philosophy might fall out of a corner of the

[1] "Quæstiones Disputatæ." De Spiritualibus Creaturis, artt. ix.-x., and De Anima, artt. ii., iii., v.

[2] Bain, "Mind and Body," p. 181.

[3] "Summa Theologiæ," prima pars, qu. ii.-xcii.

"*Summa Theologiæ*" (Sum of Theology) and hardly be missed. Yet, arrogant as this encyclopedic comprehensiveness now seems, there was really nothing else to be done. Mathematics was the only one of the natural sciences which had succeeded in disengaging itself from theology; there was no social science, no independent science even of politics; there was no history other than ecclesiastical; and (what concerns us here) there was no science of man. Man was not yet a unit in the creation, and inquiries concerning him were properly included in Cosmology, which is pagan for Theology. "*Naturam autem*," says Thomas, "*hominis considerare pertinet* ad Theologum *ex parte animæ*"[1] (It is the theologian's province to consider man's nature on the soul's side). The *theologus* kept hold of the nature of man till Descartes had emancipated him from his serfdom; but to him and his theological science—our statical factor—we may justly ascribe that first successful raising of the problem of human individuality which made possible, as we shall see, its establishment and utilization under the influence of the dynamical factor—physical science.

The fostering aid of Theology to Psychology does not, however, end when the latter is able to walk alone. All great questions subsequently raised, the settlement of which by physical methods marks each fresh stage, issue from the theological *incunabula* (cradle) where the science was reared. A history of the embryogeny of ideas would demonstrate that ideas which were afterward properly philosophical were at first purely theological. The idea of the infinite, at first negative, was made positive, through being made theological, by the Greek Fathers. Prof. Jevons believes that his "Law of Simplicity," though almost unnoticed in modern times, was known to Boëthius, and he adds:

> "Ancient discussions concerning the doctrine of the Trinity drew more attention to subtle questions concerning the nature of unity and plurality than has ever since been given to them."[2]

With greater emphasis, which, however, only exaggerates an important truth, it has been said that the doctrine of the Trinity is the "foundation of all the metaphysical thought and speculation of the ages after Gregory the Great."[3] This will be sufficiently near the mark if the honor is shared with the dogma of Transubstantiation after, say, the "captivity" at Avignon. In more recent times, especially in Germany in the first half of the present century, the doctrine of the Incarnation has been the "motive" of various metaphysical developments.

In Psychology the final cause of Locke was theological; for the rise of an *a priori* philosophy in Herbert of Cherbury was theological, and it was to overthrow apriorism that Locke undertook his examina-

[1] "Summa Theologiæ," prima pars, qu. lxxv. [2] "The Principles of Science," i., 40.

[3] Quoted in Mullinger, "History of Cambridge University," p. 55.

tion of the "original, certainty, and extent of human knowledge." Berkeley avowed that his motive, in investigating the nature of perception, was to provide a bulwark against the atheists. Hume is essentially theological, and in his "Inquiry concerning the Human Understanding," a section on Miracles stands side by side with one on the Idea of Necessary Connection. Reid wrote his "Essays on the Powers of the Human Mind" to refute Hume, and became, with this theological motive, the founder of Scotch psychology. Kant undertook his "Criticism of Pure Reason," and thus established *a priori* psychology, to show against Hume that the ideas of God, freedom, and immortality, could not be disproved by mere empirical reasoning. And the impulse which Hamilton, through Mansel, communicated to Psychology, by the new face he gave to the old problem of the Infinite, was a theological movement in its origin.

Under whatever name we give to it, under whatever form it may hereafter assume, Theology, the science of causes, essences, and origins, will play, as it has hitherto played, an important part in the development of the mental sciences, and especially of Psychology. When physical science is driving its ploughshare into untrodden regions till now only gazed down upon by the metaphysician in his balloon; when the speed of thought itself is measured; when the most complex effort of quantitative reasoning is proved to be fundamentally indentical with the simplest perception of relation; when the nature of intelligence is tracked upward in graduated sequence from the Radiata and Articulata to Newton and Shakespeare; and when the physical sides of all but the most subtle mental phenomena are being identified; the temptation is great to suppose that we are nearing the goal—that as so many laws of mind have been explained by physical laws, and so many facts interpreted in physical terms, the time is at hand, or at least will come, when the nature of causation, and of the substance of mind, and of the relation of phenomena to their source, and of that inscrutable source itself, will yield their secrets to the analysis of the inquirer armed with the weapons of physical science. Whatever power stands in the old place of Theology, which is dead—whether Metaphysics, if that be not dead also, or some "Unknowable" section of our compendiums of first principles—will show all such Comtist dreams to be vain, by eternally asking the unanswerable questions which it has been asking since the beginning of speculation. And each old question newly asked after each fresh advance of physical science tends to restore the equilibrium deranged by the operation of that dynamical factor, the history of the effects of which we will now briefly sketch.

The application of physical methods to the phenomena of mind we believe to have originated in the fact that, outside the territory which (as we saw by the quotation from St. Thomas) was sacred to the *theologus*, there was a sort of no-Man's land, which profane persons might enter into and possess. For Aquinas goes on: "Non autem ex parte corporis, nisi secundum habitudinem quam habet corpus ad animam."[1] That is to say, while the *anima intellectiva* (intellective soul), which issues directly from the hand of God, is the exclusive province of the theologian, the *anima sensitiva* (sensitive soul), which is propagated in a physical manner,[2] the passions, and the appetites, may be left to the uncowled cultivator of science as not requiring the help of divine inspiration. It was at any rate in this field that the foundations of inductive psychology were laid, and it was to the explanation of the simpler phenomena of sensibility that physical conceptions were first applied. The two greatest thinkers of the seventeenth century were almost simultaneously on the ground.

Descartes is not now remembered by his "Treatise on the Passions" (which was published within a year of Hobbes's work on "Human Nature"), and we only note it here as an early example of experimentalism in Psychology. We are more concerned to observe that his vindication of the immateriality of the thinking principle, and his clear perception of the unity of the mental aggregate, were almost contemporaneous with the "new geometry." We are not, indeed, solicitous with regard to Descartes to justify our thesis—that each advance in Psychology has been caused and conditioned by a corresponding and previous advance in physical science; for the enunciation of the Cartesian principle was less a fact in Psychology than the accomplishment of a stadium in the metaphysical evolution, which made Psychology possible. But, perhaps, it may not seem fanciful to mention that Cavalieri, "the generally reputed father of the new geometry," published in 1635 his Method of Indivisibles (which had been largely anticipated by Kepler), or to connect his leading principle—that a solid is generated out of an infinite number of surfaces placed one above another as their indivisible elements—with the effort to unite into a single substance, itself localized, the endless multiplicity of the mental manifestations. It is, at least, clear, that the application of physics to mind will follow the development of physics; and as physics has not yet advanced beyond the geometrical stage, as the period immediately preceding "Descartes's Meditations" was the epoch of a great geometrical advance, as we now know that in virtue of the *consensus* (mutual agreement) which governs all social phenomena, all the conceptions of any age are moulded in the same matrix, it seems not wholly imaginary to adduce the psychology of Descartes, who was himself an eminent geometer, as in some degree the result of the dominance of the earliest developed of the sciences.

Emerging from this doubtful region, we pass on to the *terra firma* (firm ground) of demonstrable fact. Hobbes was rather older than Descartes, but he had the advantage of delaying at least the publica-

[1] "Sum. Theol.," pt. i., qu. lxxv. [2] Ibid., qu. cxviii., art. i.

tion of his speculations until another great scientific advance had been accomplished. We cannot state his antecedents better than in his own words:

"The beginning of astronomy, except observations, I think, is not to be derived from farther time than from Nicolaus Copernicus, who, in the age next preceding the present, revived the opinion of Pythagoras, Aristarchus, and Philolaus. After him, the doctrine of the motion of the earth being now received, and a difficult question thereupon arising concerning the descent of heavy bodies, Galileus in our time, striving with that difficulty, was the first that opened to us the gate of natural philosophy universal, which is the knowledge of the nature of *motion*. So that neither can the age of natural philosophy be reckoned higher than to him. Lastly, the science of *man's body*, the most profitable part of natural science, was first discovered with admirable sagacity by our countryman, Dr. Harvey, principal physician to King James and King Charles, in his books of the 'Motion of the Blood' and of the 'Generation of Living Creatures;' who is the only man I know that, conquering envy, hath established a new doctrine in his lifetime. Before these, there was nothing certain in natural philosophy, but every man's experiments to himself, and the natural histories, if they may be called certain, that are no certainer than civil histories. But since these, astronomy and natural philosophy have, for so little time, been extraordinarily advanced by Joannes Keplerus, Petrus Gassendus, and Marinus Mersennus; and the science of human bodies in special by the wit and industry of physicians, the only true natural philosophers, especially of our most learned men of the College of Physicians in London. Natural Philosophy is therefore but young; but Civil Philosophy yet much younger, as being no older (I say it provoked, and that my detractors may know how little they have wrought upon me) than my own book, '*De Cive*' (the Citizen.)"[1]

The application of all this to the psychological philosophy of Hobbes is so patent as hardly to need elucidation in detail. Like his contemporary Descartes, Hobbes was extremely jealous of his independence, and, what was of less consequence, his originality; and one may even now hear, not without surprise and otherwise, the unlucky epigram which makes him say that, if he had read as many books as other people, he would have been as ignorant as they. Hobbes had read a great deal more than he deemed it prudent to admit, and if he had read more still the good effect of it would not have been doubtful. But, like the Greeks in the time of Sophocles, he had an advantage which would have made up for any deficiency of literary acquisition. He lived in an atmosphere heavy with ideas, and at a time when epistolary communication performed the functions very much which scientific journals now fulfill. Hobbes does not appear to have corresponded with Descartes, but he was in constant intercourse, by letter, with Mersenne, who acted as the intermediary between the two philosophers. And, as philosophers then concerned themselves with the whole range of the sciences, there was hardly a speculation stirring the European mind that need have escaped the notice of even a think-

[1] "Elements of Philosophy," Epistle Dedicatory, pp. 8, 9.

er somewhat out of the main lines of communication. Hobbes was, moreover, a traveller, had lived much on the Continent, and had possibly met Galileo at Pisa. It was under the influence of these two men, or rather of the methods they represented—Descartes and mathematics, Galileo and the laws of motion—that Hobbes proceeded to work out his philosophy. In the language of a distinguished professor, to whom we look for an exhaustive account of Hobbes's relations to the science of his time, "he set about reducing all his thoughts into the unity of a systêm, whose central idea was this of motion, and whose guiding principles were those of mathematical deduction."[1] "His great postulate," says the same writer, "is motion or mutation,"[2] and he makes copious use of it within the sphere to which Aquinas banished the experimental psychologist, and a little beyond. His explanation of sensation is wholly mechanical. The crass materialism with which he set out may have had something to do with his trenchant rejection of the audible, visible, and intelligible species of the Schoolmen, but the hypothesis which replaced them betrays its own origin. "The apparition of light," he says, "is really nothing but motion within."[3] This thesis is more elaborately developed in a passage which we quote at length, as it appears to contain an anticipation of the undulatory theory of light and heat:

> "From all lucid, shining, and illuminate bodies, there is a motion produced to the eye, and, through the eye, to the optic nerve, and so into the brain, by which that apparition of light and color is effected. . . . First, it is evident that the fire . . . worketh by motion equally every way. . . . And further, that that motion, whereby the fire worketh, is dilation, and contraction of itself alternately . . . is manifest also by experience. From such motion in the fire must needs arise a rejection or casting from itself of that part of the medium which is contiguous to it, whereby that part also rejecteth the next, and so successively one part beateth back another to the very eye," and so from the eye to the optic nerve, and from that to the brain.[4]

This postulate of motion, applied in this thorough-going manner, led Hobbes to a great discovery in the psychology of sensation. He clearly demonstrated that the secondary qualities of body arê purely subjective, and his language is almost strong enough to lead us to believe that he would have gone a long way with Berkeley. For he claims to have proved that "as in vision, so also in *conceptions* that arise from the other senses, the subject of their inherence is not the object but the sentient." If the word "conceptions" be interpreted according to a definition previously laid down in the same treatise, in which the "images produced by things" are described as conceptions, imaginations, ideas, knowledge, it should seem that he might have applied the analysis to the primary qualities as well, had the two sets of properties been as sharply contrasted as now, instead of being first dis-

[1] *Westminster Review*, April, 1867. [2] Ibid. [3] "Human Nature," p. 6
[4] Ibid., pp. 6, 7.

criminated by Descartes and Hobbes. The same conception (motion) is used to explain the feelings, which, when pleasurable, are the result of the vital motion being "helped" by the motions which, having produced conceptions in the head, afterward proceed to the heart.[1] But external objects not only "cause conceptions, and conceptions appetite, and fear;" as the latter are "the first unperceived beginnings of our actions," and as in a state of doubt, appetite and fear rapidly succeed one another, "this alternate succession of appetite and fear . . . . is that we call deliberation."[2] As all Hobbes's successors of the same school have followed him in thus ignoring the *ego*, it may be inferred that every system of experimental psychology is self-condemned to incompleteness, and that no system can cover the whole of the ground which does not make what can only be called metaphysical assumptions.

The psychological advances made by Hobbes were then—that he helped to banish the imaginary entities of the Schoolmen, and substituted for them hypotheses that implied at least *veræ causæ* (true causes); that he replaced the method of deduction from assumed principles by that of observation (which was not yet, however, that of introspection), and thus founded the inductive philosophy of the mind; and that by his summary rejection of the common metaphysical assumptions, and his patient building up on an independent foundation, he decisively separated psychology from the metaphysics in which it was enmeshed.

If the psychology of Hobbes bears evident marks of the daring, speculative character of contemporary physical science, that of Locke witnesses to the change in the tone and spirit of inquiry. If the key-word to Hobbes is Galileo, that to Locke is Sydenham. Locke and Sydenham were both surgeons, were friends, and were of kindred cautious temperament; and the pacific revolution which Sydenham wrought in medicine has been described in language that, with the necessary change of terms, might word for word be applied to the great psychological advance initiated by Locke. A competent writer describes Sydenham as being—

"most careful to exclude the prevailing theories from affecting his study of the facts of disease: he followed the inductive method which his countryman, Bacon, had just completed, and under the guidance of his friend John Locke, himself a surgeon, he applied it to the investigation of disease with splendid success. The laws ruling the prevalence of epidemics were elucidated, and new and old diseases described with an accuracy and graphic coloring which have ever since remained unrivaled. The treatment of disease Sydenham found lamentably uncertain from want of any fixed principle, and from the countless remedies prescribed mainly in accordance with a capricious fashion. In place of this, he left therapeutics an art ordered by the principle of aiding Nature, and observing the indications afforded by morbid processes themselves. . . .

[1] "Human Nature," p. 31. [2] Ibid., pp. 67, 68.

Bacon had justly reproached the physicians of his time for their neglect to make records of the cases of their patients. . . . Sydenham. . . . by his bedside study again brought it into favor." And finally, "he found English medicine reduced to the lowest state of empiricism—he raised it once more to the dignity of a science of observation."[1]

The disposition in which Locke entered on his inquiry was certainly "to exclude prevailing theories," for he has himself recorded that his Essay originated in a conviction that, before advancing to abstruse problems, "it was necessary to examine our own abilities, and see what objects our understandings were or were not fitted to deal with." His method of induction was truly Baconian: he approached the subject without any clear design, proceeded without a plan, and attained such results as can be so reached. But the "laws ruling the" formation of ideas were elucidated, and mixed and simple modes "described with an accuracy" and in one or two cases with "a graphic coloring" which have not been greatly surpassed. The philosophy of the mind he found an untrodden jungle, with a few bridle-paths in the directions marked "Sense," "Appetite," etc.; he cut a highway through the part where the bush was thickest—the region of ideas. The *a priori* method was in favor, and "bedside study" of the human patient out of fashion; the *a priori* method he did not indeed kill, but he left it to die a lingering death; and though to Hobbes belongs the honor of introducing the experimental method into Psychology, it may be truly said of Locke that he "raised it to the dignity of a science of observation." And just as Sydenham, follower of Hippocrates as he was, attributed a number of diseases to morbid fermentation in the humors, so Locke, in spite of his antischolasticism, could still assign the motion of the "animal spirits" as a "natural cause" of certain ideas.[2] The defects and the merits, in truth, of Locke's procedure were equally those of the physical science of the age. The patient observation of which Sydenham set the example gave rise to the first discriminative account—we can hardly call it analysis—of the proximate origin and more obvious constituents of our ideas. To the same causes and doubtless also to the impulse of conquest in unexplored regions which the post-mediæval world owed to Bacon, we may ascribe it that Locke's "Essay," as he named it, "inquiry," as he described it, was the first comprehensive survey of mental phenomena; while the small part which hypothesis and theory play in his investigation, his incomplete statement of mental causation of all kinds, his bare discovery of association as producing a few obvious compounds, were clearly due to the unspeculative character of the contemporary science to the influence of which he was most exposed.

Berkeley's most notable contribution to philosophy belongs rather to the metaphysics, than to the psychology, of sensation; and his less

[1] Mr. Balthazar W. Foster, in "Essays of Birmingham Speculative Club," pp. 277, 278.

[2] "Essay," book ii., ch. xxxiii.

disputed discovery of the acquired nature of our perceptions of distance we may pass over with the remark that, if the genesis of it could be traced, it would probably be found to have derived its impulse from that "century of inventions" which witnessed Snell's discovery of the law of refraction in 1624, Newton's discoveries in the composition of light in 1674, Huyghens's proof of the polarization of light about 1692, and the explanation of the structure of the eye by Petit in 1700. The conjunction will seem more than a coincidence if it is added that Berkeley's "Theory of Vision," which appeared in 1709, was preceded by Newton's "Optics," in 1705.

The next great advance of Psychology combined, in principle, the advances made by both Hobbes and Locke. As Hobbes had incorporated the conceptions of physical science, and Locke had adopted its methods, we find Hartley professing to follow the "method of analysis and synthesis recommended and followed by Sir Isaac Newton,"[1] and appropriating from the "Principia" the hypothesis of vibrations by which he explained sensation:

"My chief design in the following chapter is, briefly, to explain, establish, and apply the doctrines of *vibrations* and association. The first of these doctrines is taken from the hints concerning the performance of sensation and motion, which Sir Isaac Newton has given at the end of his 'Principia,' and in the *questions* annexed to his 'Optics;' the last from what Mr. Locke and other ingenious persons since his time have delivered concerning the influence of *association* over our opinions and affections, and its use in explaining those things in an accurate and precise way, which are commonly referred to the power of habit and custom, in a general and indeterminate one. . . . One may expect that *vibrations* should infer *associations* as their effect, and association point to vibrations as its cause."[2]

It may seem somewhat bold in Hartley, whose name has almost passed into a by-word as that of an hypothesis-maker, to shelter himself under the ægis of Newton, who declarad—"hypotheses non fingo." But, as is observed by Prof. Stanley Jevons, "the greater part of the 'Principia' is purely hypothetical, endless varieties of causes and laws being imagined which have no counterpart in Nature."[3] Psychology had reached in Hartley's time, as Natural Philosophy in Newton's time, the stage when the mere generalization of observed uniformities is no longer sufficient to cope with the accumulated multitude of ascertained facts, and when some comprehensive hypothesis is required which shall connect the empirical generalizations of one science with the ultimate laws of Nature and the principles of all the sciences. Newton's force of gravity and Hartley's theory of vibrations were such hypotheses. But, besides the intrinsic difference between them residing in the fact that the one could be proved, and the other, at best, only made probable, there was the further contrariety, which explains their very different success, that the Newtonian conception

[1] "Observations," ch. i. [2] "Ibid.," ch. i. [3] "Principles of Science," ii., 228.

was the complement of a slow development. The first natural philosophers, down even to Kepler and Galileo, had contented themselves with studying *effects*, e. g., the orbits described by the heavenly bodies, and the period of their revolutions. But, with the decay of the scholastic metaphysics, which was also physics, a new idea began to stir the minds of men—that of force. It is said to have been conceived by Nicolas of Cusa;[1] it found tortuous expression in Descartes's Vortices;[2] and, specialized as governing gravitation, it was perhaps first dimly seen by Gilbert little less than a century before Newton, was asserted by Kepler nine years later (1609), and in 1674 was stated by Hooke with remarkable clearness and accuracy—all before Newton had thrown out any hint of his sublime discovery.[3] Hartley's hypothesis, on the other hand, was a chance shot, a private guess, and was no matured result of previous theorizing. It accordingly passed into the limbo to which Nature consigns her mistakes; but the gain to Psychology was, though not equally great, of fundamentally the same kind as the gain to Natural Philosophy from the establishment of the law of gravitation. The idea of force subsumed that of law, the conception of causation superseded those of sequence and conjunction; and the basis for an explanation of the phenomena of mind was for the first time sought outside the limits of these phenomena. Hartley was unsuccessful, but the mere attempt has been as a light on high to guide the uncertain steps of later inquirers, and has at last led to the physical syntheses of our own day.

Even a false, or at least a partially true, theory has the advantage of making possible a reasoned arrangement of the facts, as well as the acquisition of more. To Hartley this hypothesis of vibrations gave strength of wing to sweep the entire field of Psychology, and we accordingly find that his was the first systematic effort to explain the phenomena of mind by the law of association.[4]

A very great advance in Psychology was made by James Mill, and it was initiated by Chemistry. During the first ten years of the nineteenth century Chemistry was revolutionized. In 1800 Nicholson and Carlisle decomposed water by means of the Voltaic pile, and enabled Davy in 1806 to make the generalizations which founded electro-chemistry. The decomposition of potassa, soda, and other bodies of the same kind, soon followed. Beginning with hydrochloric acid in 1809, the discovery of the various hydracids was made. And in 1803–'04 a great synthetic addition was made to the analytic gains; Dalton's law of chemical combination was established.[5] The influence of these brilliant discoveries upon the thought of the age was not

[1] Morin, in Migne's "Encyclopédie," *Théologie Scholastique*, s. v.

[2] Hallam, "Literature of Europe," iii. (edition 1872), p. 415.

[3] Grant, "History of Physical Astronomy," pp. 16, 17, 29.

[4] Bain, "Mental and Moral Science," p. 633.

[5] Whewell. "History of the Inductive Sciences," iii., pp. 157–159, 141, 142, 145.

doubtful. The literature of the day was drenched with metaphors taken from the dominant science. Fashion, after a long interval, once more patronized Nature, and the "bottle-and-squirt mania" spread. Experimentalism in Psychology was still under a cloud, from the discredit which had attached to the premature theorizing of Hartley. But in the early part of the century, Dr. Thomas Brown had gained a hearing, under cover of the respectable orthodoxy of the Scotch universities, for speculations thickly sown with revolutionary germs. One of his pupils was James Mill, and in 1829 that resolute and thorough-going, if narrow and aggressive, thinker published the treatise which marked the turn of the tide. Deriving his inspiration from the neglected work of Hartley, gathering up the hints freely scattered in Brown's lectures, and imbued with the spirit of the prevailing chemistry, he set about constructing a new science of mind, of which the physics should not be obsolete, and which should push the analysis of the accepted metaphysical mysteries to the farthest possible limit. He obeyed the double analytic and synthetic movement in contemporary chemical investigation. As specimens of his analytical advance, we may point to his further resolution of the apparently simple ideas of hardness and extension, which had been begun by Hartley and continued by Darwin.[1] But, as better illustrating the dynamical influence of physical science, we prefer to lay emphasis on what may, as it appears to us, be justly styled his synthetical contribution to Psychology. This was his conception, applied to the whole range of mental phenomena, of the chemical nature of association. Quite to realize the new shape which the welding mental power took in his hands, we must glance back at its history. It is comparatively young. Hobbes knew nothing of it: his "synthesis," by which things are "constructed or generated," is purely geometrical,[2] and with him association is mere sequence.[3] Locke's advance on this is clear, though inconsiderable: he speaks of the "tying together of ideas," and describes certain ideas as appearing in "gangs, always inseparable,"[4] but he regards "mixed modes" as made by men voluntarily with a view to communication.[5] Hartley, according to Mr. J. S. Mill, had reached the stage we have above stated as only attained by James Mill:

> "It was reserved for Hartley to show that mental phenomena, joined together by association, may form a still more intimate, and as it were chemical union; . . . the compound having all the appearance of a phenomenon *sui generis*, as simple and elementary as the ingredients, and with properties different from any of them."[6]

This is far too strongly stated. That the union of the associated mental elements as conceived by Hartley was more intimate than their mode of conjunction as conceived by Locke, or their rigidity of sequence

[1] "Analysis," i., 92.
[2] "Elements of Philosophy," i., pp. 312, 313.
[3] "Human Nature," ch. iv.
[4] "Essay," book ii., ch. xxxiii.
[5] "Ibid., ch. xxii.
[6] "Dissertations," iii., 108.

as imagined by Hobbes, is unquestionable; but how Mr. Mill could describe that union as chemical, and as analogous to the compound formed like water, by hydrogen and oxygen, is inexplicable if it be remembered that the composition of water was not discovered by Cavendish till 1784—thirty-five years after the appearance of the "Observations"—and that Chemistry only passed from the metaphysical to the positive stage with the deposition of phlogiston by Priestley and Lavoisier in the last quarter of the century. The following quotations from Hartley himself will confirm this *a priori* argument by showing the real nature of association as figured by him:

"Upon the whole, it may appear to the Reader, that the simple Ideas of Sensation must run into Clusters and Combinations, by Association; and that each of these will, at last, coalesce into one Complex Idea, by the Approach and Commixture of the several compounding Parts."[1]

No chemist would describe chemical union as "coalescence," or speak of the new substance produced by the operation of affinity as made up of "clusters and combinations" by the "approach and commixture" of parts. As appears still more clearly when Hartley proceeds to explain and illustrate this "coalescence," he had in his mind, as the physical type of his conception, no more "intimate union" than that combination of different kinds of matter called *solution:*[2]

"If the Number of simple Ideas which compose the complex one be very great, it may happen that the complex Idea shall not appear to bear any relation to these its compounding Parts, nor to the external Senses upon which the original Sensations, which gave Birth to the compounding Ideas, were impressed. The Reason of this is, that each single Idea is overpowered by the Sum of all the rest, as soon as they are all intimately united together. Thus, in very compound Medicines, the several Tastes and Flavors of the separate Ingredients are lost and overpowered by the complex one of the whole Mass: so that this has a Taste and Flavor of its own, which appears to be simple and original, and like that of a natural Body."[3]

We should be disposed to describe Hartley's view of mental composition as bearing a similar relation to James Mill's synthesis as Newton's composition of light to Goethe's theory of colors—as implying some species of union closer than the mechanical and less binding than the chemical. Thomas Brown clearly stated the law, as chemically conceived, in one of his introductory lectures. In mere statement James Mill's exposition is no advance upon Brown's, but the law took enormous extensions in his hands, and was applied to the senses, the feelings, memory, classification, language, ratiocination, the will, belief, etc. Something has been added to his synthesis, and a little has been taken from it, but he appears to have made as much as could be made out of the bare laws of association, unextended to the rest of

[1] "Observations," p. 74. [2] Youmans, "New Chemistry," p. 55.
[3] "Observations," p. 75.

the animal kingdom, and confined to the existing generation. His conception of the indissolubleness of certain associations, in particular, preluded the elucidation of their organic character as resulting from the intercourse of the mind with its environment.— *Westminster Review.*

THE FIELD TELEGRAPH.

By A. HILLIARD ATTERIDGE.

IN the year 1802, when Napoleon was first consul, there arrived in Paris two artisans of Poitiers. One of these men, Jean Alexandre, had invented a rudimentary form of the electric telegraph, and, with his friend Beauvais, he had left the little country town full of high hopes to submit his discovery to the great soldier who was then guiding the destinies of France. He requested a personal interview with the first consul, refusing to communicate his secret to any one else. He was referred to the astronomer Delambre, whom he succeeded in convincing of the value of his invention; still, however, declining to reveal the way in which the electric signals were transmitted, unless to Napoleon himself. But the latter refused to grant the required interview, saying he had no time to trouble himself with such matters; and Alexandre and Beauvais went back to Poitiers in bitter disappointment.[1] Had Napoleon listened to the proposals of Alexandre, the course of history might have been changed; for, had he been able to secure the exclusive possession of the electric telegraph, it is easy to imagine the effect it would have had upon his campaigns, and how difficult it would have been for even the allied armies of all Europe to contend against a great commander, who, by some secret means unknown to them, could obtain accurate and instantaneous information from every point of the theatre of war, and flash his orders to *corps-d'armée* divided from him and each other by miles of country, while his opponents had only to trust to horses and couriers to carry their orders and dispatches.

A very little study of the wars of the French Revolution, in comparison with those of our own time, will be sufficient to show what an advantage the telegraph is to the modern commander. A striking instance of the extreme difficulty of combining the operations of separate corps or armies in the same theatre of war, without the aid of the telegraph, is afforded by the history of the campaign of 1796, in Germany, when Moreau and Jourdan were "acting in concert" against the Austrians. The Archduke Charles left a weak retarding force in front of Moreau, while he directed all his available strength against Jourdan; and the former general was actually advancing in triumph

[1] Villefranche, "La Télégraphie Française, Étude Historique."

through Southern Germany, under the full conviction that his colleague had obtained a like success to the northward, while the latter had actually been defeated at Amberg, Wurtzburg, and Aschaffenburg, and driven back upon the Rhine, and Moreau only heard of his disaster in time to save his army from destruction by a hurried retreat through the defiles of the Black Forest. As a contrast to this, let us take the campaign of 1866, when the two Prussian armies advanced from separate bases into Bohemia, laying down the lines of the field telegraph as they moved forward, which, being connected by the permanent telegraphic system of Saxony, kept each army in constant communication with the other, and thus enabled them to combine their operations, and at length to unite with decisive effect on the battle-field of Sadowa.

It is just twenty years since, for the first time, the electric telegraph was used in the field, and to the British army belongs the honor of having led the way in its adoption. The trenches and batteries before Sevastopol were traversed and connected by lines of telegraph, and the French soon followed our example and constructed a similar system in their own lines; while later on a cable laid across the Black Sea put the armies in the field in direct communication with Paris and London.

Since that time a regular telegraph corps has been organized in every European army. And the field telegraph was used by the French in Italy in 1859, and in their campaigns against the Kabyles in Algeria; and, in America, both the Federals and Confederates made free use of permanent and temporary lines during the war of secession, the Southern cavalry in particular displaying great daring and enterprise in riding round the flanks of the Federal armies, seizing their telegraph-lines, sending false messages to the Northern generals, and then cutting the line and retiring as rapidly and secretly as they came. It was, however, in the Prussian army, and in the great campaigns of 1864, 1866, and 1870–'71, that military telegraphy attained its greatest development; and, after the experience of these three wars, the Prussian telegraph corps is probably the most efficient in Europe. We have already seen how well it did its work in the campaign of 1866,[1] and in 1870 it established the net-work of wires over the northeast of France, that enabled Moltke, sitting in his bureau at Versailles, to move his armies as accurately and certainly as pieces on a chess-board; while round Paris itself a circle of telegraph-wires—that in a moment flashed information of a sortie, and orders for a reënforcement of the threatened point, to every part of the long line of sixty miles, on which the besiegers lay—contributed almost as much toward the

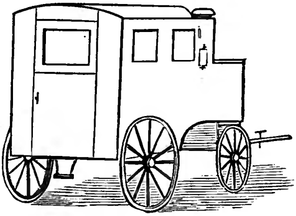
[1] During the armistice which preceded the Treaty of Prague in 1866, the Prussians displayed great carelessness about their telegraphic communications, and the troops often tore down a line to light their fires with the telegraph-poles, and tie up their horses with the wire.—(*See* Stoffel, "*Rapports Militaires.*")

reduction of the vast fortress as the circle of steel and iron, of batteries, earthworks, and redoubts, which, without the connecting link of the telegraph-wire, could not have been maintained for a single month. On their side the French displayed no less energy. The regular telegraph corps was shut up in Metz or lost at Sedan; but a fresh corps was organized for the armies of the republic, and at Paris the telegraph-lines linked together the *enceinte*, the forts and outworks, and the headquarters of General Trochu. But it was in the second siege of the capital that the French telegraph corps obtained its greatest success. During the fighting in the streets of Paris, in May, 1871, the moment a barricade was taken, a telegraph-station was established in a neighboring house, and when another post was carried the telegraph corps would again move forward with the troops, and thus MacMahon was able to watch every turn of the fight, and provide for every contingency, in a way that otherwise would have been utterly impossible. For ourselves, we have had no European war since 1854; but our armies have carried the telegraph with them into India and China, and through the ravines and passes of Abyssinia; and now the "talking wire" stretches from Cape Coast Castle through the bush, across the Prah into the heart of Western Africa, hanging on the trees, with here and there a few poles, the whole having been erected by Fantee laborers, under the direction of a handful of Royal Engineers.

The object of the field telegraph is to keep the headquarters of an army in communication with its several corps, and, at the same time, with the general telegraph system of the country. In the Prussian army, when the telegraph corps was reorganized after the war of 1866, it was formed into two divisions—the Field Telegraph Division and the Etappen Division—with a view to the more efficient performance of these two services. Both divisions consist of several companies or sections, each of which contains about 150 men, including officers, telegraph operators, pioneers, workmen for the erection of the line, and drivers for the station-, store-, and baggage-wagons. In all armies the telegraph *matériel* is, of course, very similar, and we shall therefore describe that of the Prussian army, adding a few notes on that of other countries.

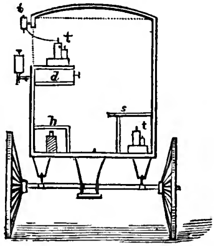
The two essential portions of the field telegraph are the station and the line. In order that there may always be a sheltered place for erecting the instruments and transmitting messages, each detachment of the telegraph corps carries with it one or more wagons fitted up as stations; but, wherever a halt of more than a few minutes is made, and there is a suitable building available for that purpose, a telegraph-station is established in it by removing the batteries and instruments from the wagon. Fig. 1 is an outline sketch of a Prussian station-wagon, Fig. 2 being a section of the same. The wagon is about 9 ft. long, with an interior height of 4 ft. 6 in., and a width of 4 ft. It is built as lightly as possible, and weighs when loaded only 14 cwt., and is easily drawn by two horses. On the outside are two insulated brass conductors *i* (Fig. 2), to which wires can be attached. Inside the windows is a shelf with a drawer *d*, on which the instrument *t* can be placed when in use, and opposite to this is a seat or bench *s* for the

Fig. 1.



Prussian Station-Wagon.

Fig, 2.



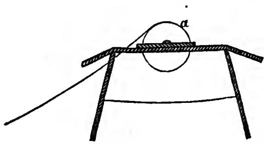
Section of Prussian Station-Wagon.

operators, on which a man can sleep at night. Under the seat is a recess in which a spare instrument *t* is kept, while the batteries are arranged in a box *b* under the shelf. When a message is to be sent from this movable station the wagon is stopped, and the line-wire is attached to the insulated conductor *i*. This is connected with the instrument and battery, and in order to complete the circuit the battery is placed in electrical communication with the second insulated conductor, to which another wire is attached which joins it to the earth-conductor or earth-stake (*piquet à terre*) (Fig. 5). Thus the course of the current, when transmitting a message, is from the battery to the instrument, and by the first insulated conductor *e* (Fig. 2) to the line of wire, the earth-plate of the receiving-station returning it to the earth-conductor, driven into the ground near the wagon, and thus back by the second insulated conductor to the battery.

The instruments are of the Morse pattern, constructed so as to fit in a very small space, and recording the signals with ink. The battery (of which there are two in each station-wagon) is a simple form of M. Marié Davy's sulphate-of-mercury battery. It consists of ten elements, one of which is shown in section in Fig. 8; *c* is a charcoal vessel, containing sulphate of mercury moistened with water to the consistency of paste, and in this the zinc plate *z* is suspended by means of the India-rubber cover I. The whole is placed in the India-rubber vessel *i*, and a copper collar *y* is added, to which a connecting wire can be attached. This battery has the advantage of being very portable, while the India-rubber cover prevents the charge of sulphate of mercury from being spilt by the motion of the wagon.

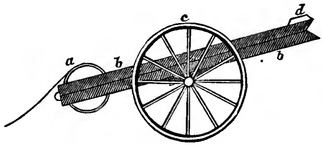
The line may be either an aërial or a ground wire, or a combination of both, the former being stretched on poles, while the latter is insulated by being inclosed in a light cable, about half an inch thick, and laid along by the road-sides or across the fields. The uninsulated wire and the cable are both issued to the telegraph corps coiled on small drums, several of which are carried by each store-wagon. In those companies which are to erect a wire stretched on poles, the wagon carries five English miles of uninsulated galvanized iron wire, one mile insulated in gutta-percha, 1,000 yards of the cable, and 200 poles with insulators attached, all the wire being coiled on twelve

Fig. 3.



Hand-barrow for uncoiling Wire.

Fig. 4.



Wheelbarrow.

drums. If it is intended to lay a ground-line, the wagon carries eleven drums of the cable, one of wire covered with a light coat of gutta-percha and tarred hemp, and a few poles and insulators, for carrying the line across small hollows, or raising it overhead in crossing roads. Beside these stores the wagon contains all the tools necessary for the work, and a light step-ladder is hung underneath it.

The wire is uncoiled from the drums by placing them successively on a hand-barrow, from which it is paid out as the barrow is carried along. The hand-barrow (Fig. 3) consists of a light iron frame, with wooden legs and handles, which are made to fold up when not in use. On this frame the drum *a* is placed; one man carries it in front and two behind, the wire uncoiling and running out between them. A wheelbarrow (Fig. 4) is sometimes employed, and is improvised for this purpose by attaching iron handles *d* to the step-ladder *b b*, and placing it on a pair of light iron wheels *c*, the drum *a* being hung in a socket near the top of the ladder.

The poles are made of well-seasoned and selected red pine, about 12 ft. long and a little more than an inch thick. At the bottom is an iron point for fixing them in the ground, and at the top a socket *s* (Fig. 6), of the same metal, with a hollow screw to receive the spindle or stem of the insulator. This consists of an iron spindle *b*, with a male screw cut in it, which supports either a cap of gutta-percha *g* or an earthen-ware cup surmounted by a metal bell. In both cases there is on the top of the insulator a metal hook *a*, in which the line-wire is hung. There are also insulators, the spindles of which terminate in spikes or sharp screws for driving into walls and trees, thus saving the trouble of erecting a post (Fig. 9).

When all the wire of the first drum is laid down, the end of it is roughly spliced on to the wire of the next drum, and the joint secured by means of the conductor (Fig. 7). This consists of two semi-cylindrical pieces of hard wood *a*, their flat side being grooved to receive the wire, and covered with a layer of India-rubber *b* to act as packing, and insulate the joint, in the case of a ground-line, and the whole is held tightly together by the brass collar and screw *c c s* (Fig. 8).

The line is very rapidly and easily constructed. In the case of a ground-line it is simply paid out from the drums on the hand or wheelbarrow, being buried in a shallow trench or elevated on poles, when it is necessary to cross a road, where the insulation of the cable might otherwise be injured by the wheels of passing vehicles. During the invasion of France the Prussians frequently avoided the roads in order to protect the line from the *franc-tireurs*, and made considerable *détours*, concealing it in woods, ravines, and water-courses. Where the uninsulated wire is used, poles are erected about fifty paces apart, the hole to receive each pole being made by driving a sharp pointed iron bar into the ground with a heavy mallet. As soon as a pole is fixed the wire

FIG. 5.

EARTH-CONDUCTOR.

is run through the hook on the top of the insulator, and stretched tight by a man holding it over his shoulder, who keeps it in this position until the next pole is ready to receive it. Wherever there are trees or walls near the line, the work is still further lightened by dispensing with the poles, and merely attaching the wire to the insulators specially constructed for this purpose. In this way the line was erected for the Ashantee expedition, the negro laborers carrying only a light ladder to ascend the trees, a small axe to clear away the boughs, and a gimlet to make a hole for the spindle of the insulator. It never took, we are informed, more than five minutes to fix an insulator to a tree; but, in those few places where trees were not available, fully half an hour was occupied in erecting each pole, and even then it was often unsteady, and had to be propped and guyed.

In Europe, where there is an extensive telegraph system in operation in every country, there is no need of the field telegraph-lines extending from the front of the army to the base of operations. Far less than this is required. All that is necessary is to connect the headquarters of the army with the nearest point on a permanent telegraph-line, and in most European countries an army in the field would seldom, if ever, be more than ten miles from such a line. Ten miles of the field telegraph can easily be erected in half a day; indeed, the

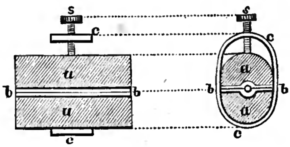
Austrian engineers assert that on favorable ground they could do the work in two hours. In most cases, of course, the advancing army would have to repair the permanent lines which would be partially destroyed by the retreating forces, and in this way twenty-five miles of wire were often erected by the Prussians in a single day. As soon as an army moves forward, the field-telegraph line previously erected is taken down and recoiled on the drums, while a fresh line is laid from the new headquarters to the nearest permanent telegraph. This is done with a view to economizing the material, an enormous amount of which would have to be carried with the army, if the lines it left behind it in its advance were not removed, and the poles, wire, and insulators, employed in their construction again utilized. The hand-barrows of the Austrian telegraph corps are designed to be used in recoiling as well as uncoiling the wire; and for this purpose are fitted with a crank-handle and ratchet-wheels, so as to enable a man to turn the drum and wind the cable upon it.

Besides the ordinary field-telegraph companies, the French army includes a mountain-telegraph corps, organized with a view to opera-

FIG. 6.

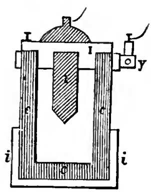
TELEGRAPH-POLE, SOCKET, AND INSULATOR.

FIG. 7.



WIRE-CONNECTOR.

FIG. 8.

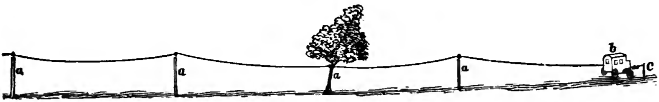


MARIÉ DAVY BATTERY.

tions on the mountainous frontiers of the south, or to be ready to carry a line over a range of hills in an ordinary campaign, thus avoiding a long *détour* in the valleys, or securing lateral communication with troops divided from the main army by the hills. As the mountain line would have to be laid along narrow, rocky paths, and through lofty passes, all carriages and wagons are dispensed with, and their place is taken by a train of mules. In a mountain-telegraph company several of the mules are each laden with two drums of the insulated cable, the instruments and batteries are carried on pack-saddles on the backs of others, and others again transport the baggage, provisions, and forage of the company, and also a light tent to form a station whenever messages are to be sent along the line.

While the field telegraph affords a commander a rapid and certain medium of communication with his base of operations and the various corps of his army, it must be remembered that it is one which is continually liable to interruption by an enterprising enemy. Wherever a general has to contend with an army well provided with good cavalry, he will find it extremely difficult to protect his telegraph-lines from being destroyed by daring raids of his opponents. There are several easy ways of making a telegraph-line temporarily useless. The simplest and most obvious method is to pull down the poles and cut the wires into pieces; but when this is done the damage is easily detected,

Fig. 9.



The Field Telegraph.—*a a a*, line-wire supported on posts and tree; *b*, station-wagon; *c*, earth-conductor.

and the repairs at once commenced. The interruption will, therefore, be far more serious if it can be effected in a way which will not permit of its exact locality being so readily discovered. This can be done by cutting the wire, introducing a piece of gutta-percha, or any other non-conducting substance, into the course of the circuit, and connecting the ends of the wires with it, so as to give it the appearance of one of the ordinary joints or splices of the line. At the same time a few poles can be pulled down in another place, and the wires cut, and the probability is that the engineers who repair the line will not discover the hidden interruption of the circuit until after they have restored the gap, and found that the wire is still cut somewhere else, and even then the place where the non-conducting substance is introduced will not be discovered until some time has been employed in carefully testing the line with the galvanometer.

But there are other dangers to telegraphic communication in the field besides the mere damage to the line. If the enemy's cavalry get possession of a station, they can easily send messages containing false information or delusive orders to well-known officers of the opposing force, while the place from which they are sent, and the assumed name in which they are dispatched, will give the messages an appearance of authenticity which, if it does not completely deceive the recipient, will at least be the cause of considerable doubt and perplexity to him, and perhaps make him hesitate to accept the accurate information or authentic orders received from other sources. Again, even without occupying a station, it is possible to read the messages which are passing along a telegraph-line, and thus perhaps discover important secrets. All that is required for this purpose is a small portable receiving instrument, and a few yards of copper wire to connect it with the line. A single individual, thus equipped, can "tap" a telegraph-line, in the daytime, by receiving the message in the ordinary way; and at night (when, of course, it would be easier to approach the line) by listening to the clicking of the armature against the electro-magnet of the instrument. But all these dangers are only of a partial or temporary character. By carefully patrolling and testing the line, it cannot be interrupted for any length of time without the damage being observed and repaired. By adopting a secret arrangement that there shall be a certain number of letters in the two or three words at the beginning or end of every message, a dispatch sent by an enemy can, in most cases, be detected; and again, by employing a cipher alphabet, it will be difficult for any one who taps the line to obtain information from the messages which fall into his hands.

From this brief sketch of the structure and uses of the field telegraph, the reader will understand what an important part it plays in modern warfare. On the march it directs the movements of advancing columns, on the battle-field it flashes orders and information with the speed of thought to right, centre, and left, of the immense lines extended over mile after mile of country; in beleaguered cities it places the whole defense from moment to moment under the eyes of those intrusted with its direction, and it is of no less value in the attack. It is not too much to say that, without this wondrous power, it would be almost impossible to direct the movements of the thousands on thousands of men, and guns, and horses, which form the vast armies of Continental Europe. It has effected a revolution in military science, none the less important because it is hidden from the general view, and seldom attracts the attention of even the ubiquitous special correspondent. Armed with all the weapons which inventive genius and mechanical skill can devise, the modern commander has the lightning also to do his work, and the electric current gliding on its secret path through the wide net-work of cable and wire tells him what is passing each hour in the remotest parts of the theatre of war, and transmits the mandates which decide the fate of nations.—*Popular Science Review.*

HINTS ON THE STEREOSCOPE.

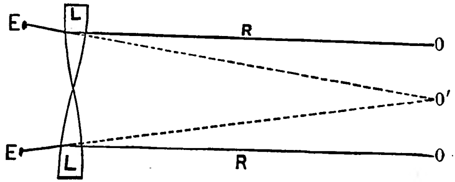
BY FRANKLIN C. HILL.

THE following diagrams will help to explain the principle on which this instrument acts. The stereoscope-glasses are halves of the same lens, placed with their outer edges toward each other (*L L*), Fig. 1. Rays of light (*R R*) from the objects (0 0), striking the oblique surfaces of the lens, are refracted outward, toward the focus, and thus reach the eyes (*E E*) in an oblique direction, appearing to come from

(0′), a point half-way between the objects. Each eye being thus deceived, the objects seem to be one.

This may be easily demonstrated by drawing on the plain back of a stereograph two similar circles, one with an horizontal and one with a vertical diameter, opposite the centres of the pictures, and, half-way between them, a heavy vertical line (as in Fig. 2). Then, looking at the card through the instrument, a circle will appear with *crossed* diameters, and with a vertical line on each side (as in Fig. 3).

Fig. 1.



By closing and opening the eyes alternately, the diameters and vertical lines will appear and disappear, but the circle will remain constant. The right eye is thus deceived into seeing the circle in the middle, and the line away to the left; and the left is deluded on the other side. The same effect may be quickly obtained by sticking a common pin upright on the middle of the rack, with a carpet-tack on each side, when a tack will be visible standing between two pins.

In selecting a stereoscope, first look that the glasses be large and heavy, and of perfectly clear glass, and see that they are wide enough

Fig. 2.

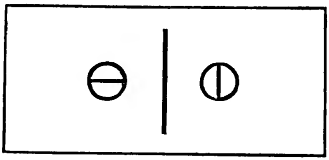
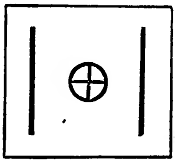


Fig. 3.



for the eyes to come opposite the middle of them, producing no feeling of being shut in by dark objects at the side. Many instrument-makers seem unaware that heads differ in width.

Then, placing a picture in the rack, see that the diaphragm hides no part of it when the rack is drawn up to a short focus. Near-sighted people have rights as well as others. Should the pictures not appear as one, remove the card and stick up a pin on each side of the rack equidistant from the middle, moving them in or out until they appear as one. If the pins have to be within two or two and a half inches of each other to "solidify," reject the instrument; but, if they meet well when farther apart, the fault was in the pictures.

A friend complained to me that the stereoscope she had bought, on my recommendation, was worthless. I had taken it on faith, supposing that all "Holmes" instruments must be good; but a short examination showed that the glasses were rather flat, and were placed so near together that the rays came to the eyes through the central part of the lens, and of course without refraction, and hence the eyes were not deceived. By whittling out the frame, and moving each glass outward about three-eighths of an inch, a good instrument was made.

If a view does not "stand out well" when seen in a good instrument, examine each picture by itself, and try to find a well-defined object, as a post or tree, in the foreground, and note its relations to some other object in the distance. If the two objects have the same relative position in both, the pictures are duplicates, and worthless.

If the distant object is to the right of the near one, they should appear farther apart in the right-hand picture, and *vice versa;* if not so, the pictures are mounted on the wrong ends of the card, and are worthless, or worse.

THE CHAIN OF SPECIES.[1]

By Hon. LAWRENCE JOHNSON.

Part I. — *Science and Religion.*

THE subject selected for this evening's entertainment—the evolution and metamorphoses of organic forms, from the genesis of life up to man—with all its difficulties, might, in skillful hands, be made amusing; but, let us rather hope for the earnestness, however dull, which will instruct, instead of the light talent which can while away an idle hour. It is a subject which has escaped from the pinfold of the learned, and become public property, at least in part; and we see it engaging the attention of news-mongers, writers of squibs, and makers of woodcuts, as well as the graver interests of literary circles, and the thunders of the pulpit.

And here let us pause a little to place ourselves right with ourselves, and right with the rest of the world.

As it is proposed to view this matter, there is not one particle of religious interest in it, any more than there would be in a lecture on geology, chemistry, or any other pure science; and, in the name of truth, system, and logic, I must protest against the unscientific, un-

[1] An address, delivered before the Franklin Society of Mobile, June 4, 1872, by Hon. Lawrence Johnson, of Holly Springs, Mississippi.

philosophical, and irreligious manner in which sacred subjects and questions are lugged into this controversy.

Science deals only with the laws of Nature, with *secondary* causes only, and can never extend to *first* and *final* causes; not that these are denied, not that the supernatural is contemned, either explicitly or by implication; he is a shallow scientist that will do so; on the contrary, the supernatural, in its true sense and position, will be assumed—*the supernatural*—that which is above—a higher than Nature, not contrary thereto, nor ever to be separated from it. "Within Nature, but not included; without, but not excluded; above it, but not taken away; underneath, and not a mere support, nor derived from it."[1] Yet it is well, and even necessary, to be sure of a safe footing upon the earth, before we lift our eyes unreservedly to the heavens.

Socrates once desired to see the day "when Nature would be explained by reason alone." This is the end and aim of all philosophy: to render all we see, and know, and think, and do, rational; to obtain rational conceptions for all things. But, remember what *explanation* is. No explanation removes *all* difficulties; solves all mysteries. Properly considered, none pretends to such a thing. Explanations only connect the unknown with the better known; the less familiar with the more familiar; new, unarranged phenomena, or ideas, with old classified facts. All classification, all science, consists of this correlation of ideas.

Now, if the scientist confines himself to the correlation of physical facts, he cannot encroach upon the domain of religion, which is devoted to supernatural beliefs and hopes; yet a skeptical religionist is always craving for some physical facts to strengthen his faith, and the superstitious scientist is always afraid of meeting with miracles. How utterly both are mistaken! No amount of wonders would impart faith to a soul already filled with doubt; nor would the scientist have the least alarm on the subject of miracles and cataclysms if he understood truly the finite and the infinite, the Creator and the creation, the reign of eternal and universal law! In going around the circle of mere cosmical relations, time and space, man finds himself bounded by the great impassable and incomprehensible Unconditioned—eternity—ubiquity. And in vain the half-learned, and all not fond of exertion, because they cannot easily comprehend the relations of the finite and the infinite, rush to the conclusion that they are in conflict, and irreconcilable; so that, in the popular mind, the human and the divine, reason and the imagination, our doubts, and hopes, and fears, have become much entangled, and like "sweet bells jangled, out of tune and harshly."

It has been beautifully remarked of the perplexing contradictions

[1] "*Supernaturale igitur, perficit quidem et elevat Naturam, non vero illi contrarium esse potest*" (The supernatural perfects and elevates Nature, but cannot be contrary thereto). (Branchereau, "Ontology," § 11, p. 6.)

often discovered in circumstantial evidence, "We only have to get hold of the right end to be able to unwind the mystery as you would a skein of thread." Nor is the narrow fear of conservative religionists to be too harshly blamed for this misapplied and unnecessary warfare. The windmills are certainly there, although they are not giants.

Filled with natural vanity at the discovery of some new fact of this wondrous life, or arrived at some new aspect of it, some new view of Nature, such pride as stirred the soul of Nuñez de Balboa when, first of civilized men, from the Cordillera of Panama, he caught sight of the great South Sea, is not unbecoming the pioneers of thought and knowledge. The danger to be guarded against is the common one of all vanity, that of mistaking partial attainment for complete victory, the achievement of a stand-point in advance assumed as the only possible one. The error is that of forgetting, like that same first beholder of the Pacific, that the apparent trend of coast depends upon the simple fact of position, the stand-point. And like him, also, it is natural, easy, and common, to conclude that the opening of some petty gulf before us is the grand expanse of the boundless ocean.

Coming in plain terms to the point before us: When a naturalist, confining himself properly to reason and the laws of Nature, speculates on the origin of species, and attempts to show the correlation of form to form, the evolution of one from another, or the development of many distinct species from a common stock, the reverence of certain minds, which have long run in a certain groove that connects these obscure mysteries of Nature with some imagined interference of Omnipotence, is seriously shocked. These, looking only to primary and final causes, feel contempt for the laborer who is working, for his penny a day, for the sight of the *next* step in that endless chain of secondary, efficient causes, which is the revelation of Nature to the rational faculty.

On the other hand, the proper conservatism of religious minds is often insulted by the exclusive cultivator of mere natural science, as the reserve and resistance of ignorance and fanaticism. Vainglorious in the light of some new discovery, he sees all the rest of the world in apparent darkness. If each—the worshiper according to the old faith, and the cultivator of the new science—understood the domain of the other better, the conclusions of both would be different.

Nor is it a few tyros in science who thus forget their true vocation, and invade a province they do not understand. When we find a Spencer and a Huxley leveling their wrath, like ordinary zealots, against what they style anthropomorphism, and issuing bulls of excommunication from their self-constituted Church of Common-Sense, against all who differ with them, against all who dare to believe in what they call the "dogma of special creations"—and even Charles Darwin, most moderate and dignified as he is of all scientists, acknowledges that "the object of his earliest work was, to combat this same dogma"—it must be admitted that the religious have grounds to fear that implacable war is to be waged against them.

Those who stand on the heights of genuine faith cannot be disturbed by such misguided attacks. Being up in the mountain of vision with the Lawgiver, they take no note of those at the base, who make golden calves for gods. But we are not all as secure in our faith as the prophet, who, according to the legend, talked with God, while none of us are without some religiosity. Where faith is only an opinion, it is not unmixed with doubt; and where there is doubt there is also fear; and anger and fanaticism are only doubt and fear applied. As the poet tells us:

> "There is no philosopher but sees
> That rage and fear are one disease."

Our popular theologians, then, whose notion of faith is opinion, and their cherished doctrines only collections and conglomerations of opinions, may well be excused for the alarm they exhibit at the assumptions of the new lights who boast themselves the disciples of reason alone, and the possessors of a positive philosophy, definite, clear, and certain.

Now, who would imagine, after all this mustering of forces, that there is not a shadow of foundation for the conflict which is so fiercely waged?

If we liken the half-armed advocates of religion, in their heterogeneous harness, to the gallant knight of La Mancha running a tilt with the windmills, we are not the less reminded of him when we witness the triumph of the new philosophers at the overthrow of the "dogma of special creations." Here, indeed, we see exemplified, also, *mutatis mutandis*,[1] that other exploit when the famous representative of chivalry swooped down upon the frightened barber and captured his pewter basin for Mambrino's helmet. In attacking and carrying off this "dogma of special creations," they have made war upon a figment of their own brains, or, at most, upon the unphilosophical, and therefore unscientific and irreligious fictions of gentlemen of their own school. Where faith is wanting, superstition and credulity abound. Strange! strange! I repeat. There is no such doctrine as that of "special creations," such as they set out in their travesty under that head, contended for as a dogma by any school of religion, pagan, Jew, or Christian.

The anthropomorphic legends and poems of infant races, necessarily anthropomorphic because poetry, which is always simple, sensuous, passionate, are not formal enunciations of rational dogma. At most they contain only the philosophy of the religion (enveloped, and therefore concealed as well as revealed), under sensuous—that is, poetic—images.

[1] The necessary changes being made.

We shall expect these new iconoclasts next to make war upon our nursery-rhymes. We cannot doubt they will soon insist upon calling on the babies to announce to them that there is no such person as Mother Goose; or bring up syllogisms in mood and figure to overthrow the dogma of Santa Claus. The sophomores are not confined to the lower classes in our colleges! Truly our age may be described as a post Santa Claus period—the age of our first pair of pantaloons. A little out of mere infancy and thoughtless trust, and not yet arrived at clear rational and moral ideas—not yet reached the "years which bring the philosophic mind." We are in a betwixt and between condition when we still eat our Christmas candy with childish gusto, but begin to suspect shrewdly that papa and mamma had something to do with filling the stockings. We do not exactly know, but our very superstition and doubt drive us to endeavor to find arguments to combat the story which once filled our childish imaginations with delight.

There is one point, then, we may set ourselves easy upon, and claim reconciliation with the rest of the world: There is no such dogma as that of special creations, announced as a systematic article of faith by any religious authority; nor philosophically discussed and contended for by any theologian worthy of the name. A few unwary ones, like Hugh Miller, more skilled in rocks than in the theology in which he thought he believed, may, now that the question is raised, have confounded the Genesis of Species with the more general idea of Creation; and may have followed their antagonists into blunder after blunder.

It is no reply to this position to point out the fact that eminent religious teachers, such as Balmez, or even St. Augustine, at times spoke of the creation of species. For that matter, it is not unphilosophical to speak of the creation of individuals, and that with the instrumentality of immediate parents before our eyes. But, granting these to be mistakes of said doctors of theology, nothing is concluded thereby. For even our lawyers in the ordinary practice of the courts will tell you that *obiter dicta* of a judge decide no law. Innumerable instances occur in their daily practice when the judges, declaring and announcing correctly the general principles of law, yet make the most absurd and illogical application to particular facts and cases, and that even on points actually before the court; much more upon questions only incidentally brought in upon their own motion. Hence the general rule of logic in such matters: that general rules take precedence of particular applications.

The same rule applies here: for it is fact that this question, exactly as we now put it, never was before the court until formally raised in this plea of evolution.

But, to go back through the literature of the case: From very remote periods, even of Greek philosophy, discriminating analysis is compelled to discover that the question is not so much of a creation, as of a rational conception of the creation—not of the fact, but of the method.

Religious faith does step in, where science fails, to say how the Cosmos began, and is ordered and sustained in perpetual harmony. Physical science, of course, has nothing to do with first and final causes, and therefore answers: "We cannot tell whether the Cosmos is eternal, or began in time." It is a higher philosophy that comes in to answer, with the irresistible definitions of a higher logic, that it began in time. According to the very terms of the proposition, matter is bounded by space and time, and exists only in, by, and through these limitations. Consequently, it is even a contradiction in terms to ask the question, whether it is eternal or not. It is the same absurdity as to ask if the finite be infinite; if the limited be ubiquitous; if the conditioned be unconditioned.

Again: Religion, sustained also by a true philosophical ontology, asserts that the relation of the infinite to the finite—of the eternal to the limited—is that of a Creator. For, if this is not so, then they must be of the same substance—that is, identical, which again is absurd by the very terms of the proposition.

Having the creation—the basement-matter—let us proceed to its metamorphoses. And here, coy as sea-born Thetis, it will take the valor, the skill, and the passionate pursuit of heroes worthy to wed immortal brides, to follow Nature through her protean form and into her concealed recesses.

These metamorphoses depending upon the elements of the Cosmos—upon the laws with which matter is endowed (and it would not be matter, remember—this Cosmos which we know—without them)—the investigation is strictly, and without the least irreverence, the legitimate province of rational physical science. It is as religiously a duty to make use of the reason to comprehend and "justify the ways of God to man," as it is, through faith and love, to adore him.

The *method* of creation, then, it is, and not the *fact*, that natural science deals with. It invites our attention to physics, simply, and leaves metaphysics to a higher school.

When, therefore, these doctors of the new school tell us that they are about to overthrow religion in one of its old dogmas—namely, as they define it themselves, that the Creator came here, and, like a potter upon his wheel, out of distinct lumps of clay, in certain definite periods, produced certain definite forms, which forms, in organic creatures, are species, and which may perish or endure, but cannot change—it is easy to see that they have not themselves risen above that anthropomorphic conception of Deity which they assume to condemn. They are still struggling with eyes half open to realize whether it is Santa Claus or papa in his nightcap. In a word, they have not arrived at the conception of the Creator as infinite and eternal, and that his acts are in eternity, not in time. Nor have they a conception of a creation by law—a creation through the Logos—that eternal Reason, that all-providing Wisdom—whose hand stretched the line upon it, and whose right hand held the plummet; a scintilla of which enlightens every man that cometh into the world. Talk of their bringing forward this doctrine of evolution as a new discovery! They have, indeed, elaborated it in many new applications, but, as to the doctrine itself as a new proposition in philosophy, it was already old when Pythagoras was a school-master. Evolution new in philosophy, and the poetic or anthropomorphic notion of special creations a dogma of theology! Why, we are almost tempted to believe, with the satirist, that "nowadays men read every thing but books!" Even the (so-called) narrow-minded, ignorant schoolmen of the dark ages (very dark to those who consult not the numerous authors of the period)—even these made a broad distinction between the act, so to speak, the moment which called matter into existence, and that which merely modifies its forms and appearances. The former they dignify with the supreme title, creation (*creatio*), while the latter they called eduction or evolution (*eductio*). Looking to the continuance of the creative energy, and yet according to the law—according to, and by, definite and fixed properties, so to speak, with which matter is endowed—the term *eduction* is generally preferred by them; but *evolution* is also used for the same thing indifferently. And a late author, but of the same school in metaphysics, summing up their cosmological doctrines, and showing a reconciliation of the controversy concerning the relation of the Creator to the universe, from their point of view, known as the doctrines of harmony and assistance, says that the advocates of the latter doctrine taught that "God works not in his creation except according to the constant and general laws determined from the beginning" (Branchereau, "Cosmology," p. 70). And the still more general doctrine, also maintained by them, that "all beings admit of evolution by gradations to perfection according to their several natures," goes as far as Mr. Spencer, or any other philosopher, has gone, in the enunciation of general principles on this subject, and from a more elevated position (Branchereau, "Ontology," p. 56).

This very fact, that the highest theological philosophers and doctors, from St. Augustine down to our own times—as shown by Mr. Mivart and others—have never had any difficulty on the subject of the abstract question of the creation of the Cosmos, and the eduction of infinite variety from primordial matter by and according to constant law, however ignorant the same authors may have been of facts in Nature, and however jejune their notions of history and physics, ought to be sufficient to quiet us as to the legitimacy of our investigations; in short, that there is no more danger to orthodoxy (as the word is) in this endeavor to discover and trace the steps and stages of the development of life, than there is in the application of chemistry to the analysis of minerals, of geology to the classification of the earth's strata, or of astronomy to the calculation of the motions and relations of the heavenly bodies.

Nor is there any more mystery in one than in the other. Of course, in biology, the process is more complicated—more difficult to comprehend—but not incomprehensible. Indeed, as will be seen at the proper time, the mysteries of daily occurrence, such as growth, budding, and reproduction, are as great as any which beset the passage from form to form, from species to species. No one who has thought of it sufficiently can deny that the ordinary facts of generation, as the necessity of the union of two cells of nearly-spent vitality to produce a third cell, or a brood of cells, endowed with primeval vigor, present difficulties more unsurpassable than the origin of the germs of living things from inorganic matter; or that the preservation of species, by like producing like, is more difficult of explanation than the beginning of new species by variations in the reproduction, which, as a fact, is more likely to occur than the resemblance. The genesis of life from the inorganic kingdom we can begin to comprehend, because it is more simple and can be referred to known physical forces; but the other —that is, reproduction—is still wrapped in impenetrable obscurity.

A glance at the history of this controversy will make the whole matter clear, and, as remarked, ought to set us right with the rest of the world.

In the dawn of science as we know it—that is to say, in the rise of the Greek philosophy—no other view of creation was thought of than that which modern induction now demands, because, happily for them, there was not in their possession any supposed revelation on the subject, and there was no school which thought of any other solution of the problem than one which could be deduced from observation and speculation. Yet they suggested little that would now be of benefit, the range of their facts and of their analysis being too much limited.

The moderns, notwithstanding that the general principles of the philosophy, and of the philosophical theology of the middle ages were, as we have seen, favorable, have cramped and trammeled themselves with many irrelevant matters. The so-called skeptics are not alone to blame for the unnecessary conflict existing between Religion and Science. In the great religious revolutions of the sixteenth century (incident to revolutions in empire and commerce), from the excitement of religious parties theology and polemics assumed the lead in literature and thought. And such was the increased importance given to individual opinion, arguments, and scholarship, that it is often difficult to separate the idiosyncrasies of the author from the general cause he advocated. In their appeals to history as the principal method of discussing divinity, it was natural that each scholar should, consciously or unconsciously, adopt some scheme of universal history; and it was also natural that there should be an almost universal concurrence in their views of primitive times, because there was nothing in their disputes about the dogmas of Christianity to bring the early ages of man and of the earth into discussion. When, therefore, the skeptics, in their profound ignorance of theology and of the higher philosophy, ran against these sand-bags of individual opinions, it was natural for them to suppose that they had discovered the very citadel of religion; although, as we have seen, these anthropomorphic schemes are no more like religion than the play-house earthworks of children, piled up some summer's day on the sandy shore, are like Fort Morgan. Yet, from this simple psychological connection in their growth, history, science, and theology, since that period have been polemical; and, when, by the application of truly rational and scientific methods, thinking men began to construct the natural history of the earth from the facts recorded in the strata of its crust, and it began to be seen that all organic forms are modeled upon one common plan and developed out of primordial types under the operation of natural laws, an alarm was sounded, as if the principles of Faith were really involved, and in danger of impending overthrow. In their alarm and trepidation the guardians of the dimly-comprehended regions of Religion, regarding all who wander out of the beaten paths of knowledge as "false knaves," begin their examinations always, like a certain famous magistrate, with the question, "Masters, do you serve God?" and insist that "God" shall be written first, "for God forbid but God should go before such villains."

On the other hand, again, as remarked, there are scientific men who would also be philosophers, who suppose the anthropomorphic, that is, the poetic expressions of religious conceptions, to be essential to and the very gist of worship. Not having arrived at any thing beyond anthropomorphic notions of the Deity themselves, they weakly imagine that no other are possible; that there is no religion, no religious worship, nothing to lift man out of and beyond himself into the contemplation of the unexpressed sublimities of the Infinite and the Almighty, except the legends of the miracles and wonders of remote ages. Hence one of them now boasts that, in the advance of science, "anthropomorphism" (by which he means religion itself) "is driven to its last intrenchment—the mind and heart of man himself." When was it ever anywhere else? When was it ever any thing else (that is the expression of it) than a development of the imagination—the faculty of faith—the æsthetical faculty—that which lifts man above the clods of earth and makes him akin to the immortal and the divine? For is not religion both a science and an art?—from the inductive point of view as truly a science as any other, and the climax and crowning glory of all the others? and also an art, a fine art, as truly as any other, and the most divinely beautiful of them all?

Alas for the philosopher who thinks it driven to the last ditch!

He confesses his defeat when he sadly admits this last intrenchment impregnable; for here, he says, "it must ever remain a drawn battle." Rightly understood, not a drawn battle, but a victory to Religion, the possessor of the citadel—a victory which grows more and more decisive the more it is perceived that the "mind and heart of man himself" is the only territory it ever claimed—the only dominion it ever attempted to defend. After all, is not the simple admission of a devout mind, when it meets with some inexplicable fact—"God made it so"—more philosophical than the shallow assertion of presumptuous science, "We can never know?"

CLIMATE AND SOCIAL DEVELOPMENT.[1]

By HERBERT SPENCER.

LIFE in general is possible only between certain limits of temperature; and life of the higher kinds is possible only within a comparatively narrow range of temperature, maintained artificially if not naturally. Hence it results that social life, presupposing as it does not only human life, but that life vegetal and animal on which human life depends, is restricted by certain extremes of cold and heat.

Cold, though great, does not rigorously exclude warm-blooded creatures, if the locality supplies in adequate quantity the means of generating heat. The arctic Fauna contains various marine and terrestrial mammals, large and small; but the existence of these depends, directly or indirectly, on the existence of the inferior marine creatures, vertebrate and invertebrate, which would cease to live there did not the warm currents from the tropics check the formation of ice. Hence such human life as we find in arctic regions, dependent as it is mainly on that of these mammals, is also remotely dependent on the same source of heat.

Here the fact we have to note is that, where the temperature which man's vital functions require can be maintained with difficulty, social evolution is not possible. There can be neither a sufficient surplus power in each individual nor a sufficient number of individuals. Not only are the energies of the Esquimaux expended mainly in defending himself against loss of heat, and in laying up stores by which he may continue to do this during the arctic night, but his physiological processes are greatly modified to the same end. Without fuel, and, indeed, unable to burn within his snow-hut any thing more than an oil-lamp, lest the walls should melt, he has to keep up that bodily warmth which even his thick fur dress fails to retain, by devouring vast quan-

[1] From advance sheets of the "Principles of Sociology.—Part I. The Data of Sociology. Chapter III. Original External Factors."

tities of blubber and oil; and his digestive system, heavily taxed in providing the wherewith to meet excessive loss by radiation, supplies less material for other vital purposes. This great physiological cost of individual life, indirectly checking the multiplication of individuals, arrests social evolution.

A kindred relation of cause and effect is shown us in the Southern Hemisphere by the still more miserable Fuegians. Living nearly unclothed in a region of continual storms of rain and snow, which their wretched dwellings of sticks and grass do not exclude, and having little food but fish and mollusks, these beings, described as scarcely human in appearance, have such difficulty in preserving the vital balance in face of the rapid escape of heat, that the surplus for individual development is narrowly restricted, and, by consequence, the surplus for producing and rearing new individuals. Hence the numbers remain too small for exhibiting any thing beyond incipient social existence.

Though, in some tropical regions, an opposite extreme of temperature so far impedes the vital actions as to impede social development, yet hindrance from this cause seems exceptional and relatively unimportant. Life in general, and mammalian life along with it, is great in quantity as well as individually high, in localities that are among the hottest. The inertness and silence during the noontide glare in such localities do, indeed, furnish evidence of enervation; but in cooler parts of the twenty-four hours there is a compensating energy. And if it is true that varieties of the human race, adapted to these localities, show us, in comparison with ourselves, some indolence, this does not seem greater than, or even equal to, the indolence of the primitive man in temperate climates.

Contemplated in the mass, the facts do not countenance the current idea that great heat hinders progress. Many societies have arisen in hot climates, and in hot climates have reached large and complex growths. All our earliest recorded civilizations belonged to regions which, if not tropical, almost equal the tropics in height of temperature. India and Southern China, as still existing, show us great social evolutions within the tropics. And, beyond this, the elaborate architectural remains of Java and of Cambodia yield proofs of other tropical civilizations in the East; while the extinct societies of Central America, Mexico, and Peru, need but be named to make it manifest that in the New World, also, there were in past times great advances in hot regions.

It is thus, too, if we compare societies of ruder types that have developed in warm climates, with allied societies belonging to colder climates. Tahiti, the Tonga Islands, and the Sandwich Islands, are within the tropics; and in them, when first discovered, there had been reached stages of evolution that were remarkable considering the absence of metals. So that, though excessive heat hinders the vital actions, not only of man as at present constituted, but of the mammalia generally, such heat hinders the evolution of bodily energy only during part of the day, and, by the abundance of materials for living which it fosters, aids social development in most ways more than it impedes it in some ways.

I do not ignore the fact that in recent times societies have evolved most, both in size and complexity, in temperate regions. I simply join with this the fact that the first considerable societies arose, and the primary stages of social development were reached, in hot climates. Joining these two facts, the entire truth would seem to be that the earlier phases of progress had to be passed through where the resistances offered by inorganic conditions were least; that, these phases having been passed through, and the arts of life having been advanced, it became possible for societies to develop in regions where the resistances were greater; and that further developments in the arts of life, and further discipline in coöperation going along with them, enabled societies inheriting the resulting advantages to take root and grow in regions which, by climatic and other conditions, offered relatively great resistances.

Taking the most general view of the facts, we must therefore say that, solar radiation being the source of those forces by which life, vegetal and animal, is carried on, and being, by implication, the source of the forces displayed in human life, and consequently in social life, it results that there can be no considerable social evolution on tracts of the earth's surface where solar radiation is very feeble. We see that, though, contrariwise, there is on some tracts a solar radiation in excess of the degree most favorable to vital actions, yet the consequent hindrance to social evolution is relatively small. Further, we conclude that an abundant supply of light and heat is requisite during those first stages of progress in which social vitality is small.

Passing over such traits of climate as variability and equability, whether diurnal, annual, or irregular, all of which have their effects on human activities, and therefore on social phenomena, I will name here one other climatic characteristic that appears to be an important factor. I refer to the quality of the air in respect of dryness or moisture.

Either extreme brings indirect impediments to civilization, which we may here note before observing the more important direct effects. That great dryness of the air, causing a parched surface and a scanty vegetation, negatives the multiplication needed for advanced social life, is a familiar fact. And it is a fact, though not a familiar one, that extreme humidity, especially when joined with great heat, may raise unexpected obstacles to progress; as, for example, in some parts of East Africa (Zungomero), where, according to Captain Burton, "the springs of powder-flasks exposed to the damp snap like toasted quills; . . . paper, becoming soft and soppy by the loss of glazing, acts as a blotter; . . . metals are ever rusty; . . . and gunpowder, if not kept from the air, refuses to ignite."

But it is the direct effects of different hygrometric states which must here be more especially set down—the effects on the vital processes, and therefore on the individual activities, and, through them, on the social activities. There is good reason, inductive and deductive, for believing that the bodily functions are facilitated by atmospheric conditions which make evaporation from the skin and lungs tolerably rapid. That weak persons, whose variations of health furnish good tests, are worse when the air, surcharged with water, is about to precipitate, and are better when the weather is fine, and that such persons are commonly enervated by residence in moist localities but invigorated by residence in dry ones, are facts generally recognized. And this relation of cause and effect, manifest in individuals, is one which we may suspect holds in races—other things being equal. In temperate regions, differences of constitutional activity due to differences of atmospheric humidity, are less traceable than in torrid regions, the reason being, that the inhabitants are subject to a tolerably rapid escape of water from their surfaces, since the air, though well charged with water, will take up more when its temperature, previously low, is raised by contact with the body. But it is otherwise in tropical regions where the body and the air bathing it differ much less in temperature, and where, indeed, the air is often higher in temperature than the body. Here the rate of evaporation depends almost wholly on the quantity of surrounding vapor. If the air is hot and moist, the escape of water through the skin and lungs is greatly hindered; while it is greatly facilitated if the air is hot and dry. Hence, in the torrid zone, we may expect constitutional differences between the otherwise-allied inhabitants of the low, steaming tracts and the tracts which are habitually parched with heat. Needful as are cutaneous and pulmonary evaporation for maintaining the movement of fluids through the tissues, and thus furthering molecular changes, it is to be inferred that, other circumstances being alike, there will be more bodily activity in the people of hot and dry localities than in the people of hot and humid localities.

The evidence, so far as we can disentangle it, justifies this inference. The earliest recorded civilization grew up in a hot and dry region—Egypt; and in hot and dry regions also arose the Babylonian, Assyrian, and Phœnician civilizations. But the facts when stated in terms of nations are far less striking than when stated in terms of races. On glancing over the rain-map of the world, there will be seen an almost continuous area marked "rainless district," extending across North Africa, Arabia, Persia, and on through Thibet into Mongolia; and from within, or from the borders of, this district have come all the conquering races of the Old World. We have the Tartar race, which, passing the southern mountain-boundary of this rainless district, peopled China and the regions between it and India—thrusting the aborigines of these areas into the hilly tracts; and which has sent successive waves of invaders not into these regions only, but, from time to time, into the West. We have the Aryan race, overspreading India and making its way westward through Europe. We have the Semitic race, becoming dominant through North Africa, and, spurred on by Mohammedan fanaticism, conquering parts of Europe. That is to say, besides the Egyptian race, which, seeming by its alliances to have originally been of low type, became powerful in the hot and dry valley of the Nile, we have three races, widely unlike in type, and speaking languages classed as fundamentally distinct, which, from different parts of the rainless district, have spread as invaders over regions relatively humid.

Original superiority of type was not the common trait of these races: the Tartar type is inferior, as well as the Egyptian. But the common trait, as proved by subjugation of other races, was energy. And when we see that this common trait, in races otherwise unlike, had for its concomitant their long-continued subjection to these special climatic conditions—when we find further, that from the region characterized by these conditions, the earlier waves of conquering emigrants, losing in moister countries their ancestral energy, were overrun by later waves of the same races, or of other races coming from this region, we get strong reason for inferring a relation between constitutional vigor and the presence of an air which, by its warmth and dryness, facilitates the vital actions.

A striking verification is at hand. On turning to the rain-map, it will be seen that, of the entire New World, the largest of the parts distinguished by the absence of shade as almost rainless, is that Central American and Mexican region in which indigenous civilizations developed; and that the only other rainless district is that which formed part of the ancient Peruvian territory—the part, moreover, in which the pre-Inca civilization has left its most conspicuous traces. Inductively, then, the evidence justifies in a remarkable manner the physiological deduction.

Nor are there wanting minor verifications. Comparisons among African races are suggestive of similar contrasts in constitution, similarly caused. Of the varieties of negroes Livingstone remarks ("Missionary Travels," p. 78): "Heat alone does not produce blackness of skin, but heat with moisture seems to insure the deepest hue;" and Schweinfurth, in his lately-issued "Heart of Africa," similarly remarks on the relative blackness of the Denka and other tribes living on the alluvial plains, and contrasts them with "the less swarthy and more robust races who inhabit the rocky hills of the interior" (vol. i., p. 148). There seem, generally recognizable, corresponding differences in energy and social advance. But I note this difference of color arising in the same race, between those subject to a moist heat and those subject to a dry heat, for the purpose of suggesting its probable connection with the fact that the lighter-skinned races are habitually the dominant races. We see it to have been so in Egypt. It was so with the races spreading south from central Asia. There is evidence that it was so in Central America and Peru. And if, heat being the same, darkness of skin accompanies humidity of the air, while relative lightness of skin accompanies dryness of the air, then, in this habitual predominance of the lighter-complexioned varieties of men, we find further evidence that constitutional activity, and in so far social development, is favored by a climate conducing to rapid evaporation.

I do not mean that the energy thus resulting determines, of itself, higher social development: this is neither implied deductively nor shown inductively. But greater constitutional activity, making easy the conquest of less active races and the usurpation of their richer and more varied habitats, also makes possible a utilization of such habitats that was not possible to the aborigines.

THE HYDRAULICS OF GREAT RIVERS.

AN important advance in our knowledge of hydraulics has been recently effected through the observations of M. Révy, a member of the Institute of Civil Engineers of Vienna, on the great rivers of Paraná and Uruguay in South America. The results of his observations have just been published in England, in a book entitled "The Paraná, the Uruguay, and the La Plata Estuaries," an excellent account of which appears in the April number of the *Edinburgh Review*, from which the following statement is derived. Before giving the details and results of M. Révy's observations, it is advisable to furnish a brief description of the character and appearance of the streams observed.

The La Plata is simply an estuary or arm of the sea into which empty the Uruguay and the Paraná. It trends in a northwesterly direction, is 70 miles wide at its mouth, and 150 long to the mouth of the Uruguay. Higher up still it loses itself in the Paraná Guayaza and the Paraná de las Palmas, *embouchures* of the Paraná proper, which branches 72 miles above to form a delta. The Uruguay and the Paraná are the main arteries of the vast basin formed by the Andes on the west, the mountain-chain which runs parallel with the Atlantic Ocean on the east, and on the north by the great range of Cordilleras which stretch directly across the South American Continent at the fifteenth parallel of south latitude. Their water-shed is the southern slope of these Cordilleras, while that of the Amazon is the northern slope. Of the two rivers, the Paraná is much the larger, being second only to the mighty Amazon in size. It maintains an almost uniform width of three-fourths of a mile to a mile, and a depth of 50 to 70 feet for 852 miles, in a comparatively direct line from its mouth to the confluence of the Paraguay. Above this point it is not navigable except for small vessels, at certain seasons of the year; but the Paraguay, which is undoubtedly entitled to be considered the main stream, is navigable for 1,000 miles farther. The banks of the Paraná Guayaza rise only about two feet above the water, but are of firm soil. They are covered with dense forests of a glossy-leaved tree called *sieba*, somewhat resembling the laurel, and a thick undergrowth of rushes. The scenery retains this general character for 98 miles, where a bluff is sighted on the right or southwest bank of the river. About ten miles higher up, the river rushes with great force through the Straits of Obligado, a pass between two steep bluffs, about half the regular width of the river apart. At this point the stream is 150 feet deep. Excepting at this place, the left bank of the river is formed by an immense, low swamp, from 15 to 30 miles in width, for 253 miles from the mouth, while the right bank, for 100 miles above the straits, is formed by the high table-land of Buenos Ayres. The first cataract of the Paraná occurs about 150 miles above the confluence of the Paraguay, and it is this which renders the upper part of the river unnavigable, except for small vessels, during the floods which annually occur. About 550 miles above this cataract are the Falls of Guaira. These are not perpendicular, as Niagara, but inclined at an angle of about 50° from the horizon, with a fall of 50 feet. Above the falls, the Paraná is 4,500 yards wide, from which it suddenly contracts between granite walls 70 to 80 yards apart. Into this pass the water rushes with such tremendous fury, that clouds of spray arise and fall in perpetual rain over the neighborhood; the roar is such that no other sound can be heard, and the listener is made deaf by the thunder; even the very earth trembles, so that it has become desolate.

The Uruguay, a great river by itself, is almost insignificant in comparison. At the mouth, its channel is broad and deep, but at 200 miles above it dwindles into a torrent six feet deep, flowing through a rocky pass 145 feet wide. It is, however, subject to floods in September and October, during which it rises at the rate of three feet per day to 50 feet above the usual low-water line. At this time, the volume of the river is greatly increased by enlargement of the waterways, and a more than tenfold increase in the velocity of the current, which, at ordinary times, is about five miles per hour in the pass described.

The Paraná, on the other hand, although, as we have already seen, similarly subject to an annual overflow, displays nothing like the violent fluctuations of supply belonging to the Uruguay. M. Révy tells us that the ordinary annual rise at Rosario, 189 miles from the mouth of the Paraná Guayaza, where the river is about three-fourths of a mile wide, is 12 feet, and that the flood-level is always maintained for three months. The river occasionally rises to 24 feet above the low-water line, but this is rare, and its low-water supply never falls below half the volume of the ordinary flood. At a 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 depth increases by a gentle and regular slope, from that of a few inches, on the left shore, to 72 feet, at a distance of about 1,100 feet from the right bank. Thence it rapidly shallows to about 12 feet, and then rises gradually to the foot of a vertical cliff, forming the right-hand shore of the river." These measurements were made in January, when the river was at low water. The average depth was 47½ feet, and the greatest 72 feet, while the sectional area measured 184,858 feet. The same section, during the ordinary flood, gives a measurement of 243,000 feet, or a little less than one-third greater. This, however, does not give an adequate idea of the increase in volume, as, at the height of the flood, the left bank of the river is submerged for many miles. The flow, independent of the escape over the marshes, is estimated, according to M. Révy's data, as 40,000,000 metric tons per hour at low water, 83,000,000 at the ordinary flood, and 169,000,000 at the occasional extraordinary floods.

The velocity of a river depends upon the inclination or fall of its course, and its surface velocity can be ascertained by determining the rate of that fall per mile, and *vice versa* we can ascertain the inclination by measurement of the surface velocity. But, as every one who has stirred up the bottom of a brook has observed, the surface-current flows faster than the under-current. The particles of sand at the top of the water are always carried some distance beyond those at the bottom. This retardation of the under-current is caused by the friction of the water against the bottom and sides of the brook. 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. "Thus if a shoal occurs in the middle of a channel, the velocity of the current over the shoal is less than that of the deeper water on either side; and this diminution of speed is proportionate to the loss of depth. So direct is this relation, that a plan of the surface velocities, if projected on an appropriate scale, coincides very closely with the section of the bottom of the river. Any want of parallelism between the two curves is capable of explanation either by the curvature of the banks, or by some physical irregularity of the channel." 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." This decides that the mean velocity of a stream is to be found at half its depth. A result perfectly consistent with the previously expressed law that surface velocity is proportionate to depth, it is in fact a corollary, and one that was verified by experiment.

For determining the velocity of a stream, M. Révy employed an instrument called the current-metre. This consisted of a propeller-like wheel attached to a long axle and made to turn with rapidity when immersed in a running stream. The wheel is fastened to a kind of rudder which keeps it always against the stream. The upper end of the axle moves a set of cogs which turn a couple of indices upon a dial-plate. M. Révy is not the inventor of the instrument, but he improved it so as to greatly increase its utility. He first ascertained the correct reading of the metre by moving it through still water, and next made an extensible addition to the axle, so that the instrument could be adjusted to any depth.

An interesting verification of M. Révy's discoveries with regard to the velocity of currents was unexpectedly made. "In two successive measurements of the current of the La Plata, he found that there was a decrease of surface velocity and an accompanying increase of lower velocity. This at first seemed to contradict his previously-obtained results, but on further examination it was discovered that the depth at those points was sixteen inches greater. The water was banked up by its own mass so that the surface fall was less than at the point of previous measurements. "In obedience to known hydraulic law, this decreased surface-inclination was indicated by decreased velocity of surface-current. But the power of the whole moving mass was greater in proportion to its depth. And thus, while to the superficial gaze the velocity was less, the mean velocity was greater; and the river swept with more resistless energy over its bed. This luminous observation is the opening of an entirely new chapter in hydraulic science. It is, in fact, a case of the law of relation of speed to depth; but it is one that could scarcely have been arrived at by theory; although, now that it is experimentally ascertained, its theoretic reason is ascertainable."

These results, of course, require further verification elsewhere, but they cannot fail to be of the highest value both to experimental and practical science, for they will at any rate furnish method, and give new impetus to hydraulic investigation. Should they be verified, and they probably will be, it will follow that wherever water-power is desired, as in mill-races, or abundance of water-supply, as in aqueducts, depth of way should be secured at the expense of breadth.

And again, they will render valuable aid to the science of meteorology. We have as yet no knowledge of the constants of evaporation from water-surfaces. On this point the Edinburgh Reviewer remarks: "An unusually favorable opportunity now presents itself for the actual determination of the most steady and remarkable case of evaporation that occurs on the surface of our planet. In its headlong course from the foot of Hermon, the Jordan (well named *the descender*) may almost be said to consist of three continuous cataracts, divided by two lakes and terminating in a third. From the surface of that bituminous sea, the whole supply brought down by the Jordan and its affluents is exhaled in invisible vapor. By an accurate measurement of the volume discharged by the Jordan, we shall be furnished with evaporative data of the highest value."

ANIMALS EXTINCT IN THE HISTORIC PERIOD.

By EMILE BLANCHARD.

TRANSLATED FROM THE REVUE DES DEUX MONDES, BY A. R. MACDONOUGH.

ALL beings are exposed to more or less frequent dangers, and are constantly struggling to defend their lives. They have to dread the inclemency of the seasons, and must perish if they fail to find a sufficiency of food; the herbivorous are destined to become a prey to the carnivorous, and, when there seems no need of a victim, deadly battles occur for the possession of a place or the conquest of a prize. Destruction is a natural law; but this destruction is restrained within certain limits: notwithstanding the perils that incessantly threaten the existence of all creatures, every thing works actively to secure the maintenance of races. That instinct of preservation which goads individuals to fly from danger and seek the satisfaction of their material wants, allows many to escape accidents. If the causes of violent death vary within the widest range among animal species, they are always proportioned to the causes that protect against it. Fecundity, restricted among powerful animals, and limited also in those that have only the attacks of the strongest to fear, is prodigious among the weakest that are doomed to yield a multitude of victims. Thus the complete disappearance of any species is only possible under wholly exceptional conditions. Usually, the species destroyed at one point continues to propagate itself at another: if abundant at one period, it is rare at another, when circumstances become unfavorable; yet it has not ceased to be represented, in some corner of the world. Certainty in this respect has been gained by exact and very numerous observations. Since the day when the last grand physical phenomena were completed on the surface of the globe, few animals have disappeared. Only some great species have become extinct, and man alone is the author of that extinction, so much to be regretted. It has been supposed that species, like individuals, were doomed to perish. It might be difficult to form any other conclusion, were we to consider the relics of those beings that have lived in the different geological periods; but if we examine the world as it exists we are forced to reject that belief, except on the supposition that new disturbances will hereafter occur on our globe.

I.

While Central Europe, almost completely given up to Nature, was covered with vast forests and its inhabitants were thinly scattered, animals found few obstacles to their increase. The great species, quite rare in our time, were common in very many localities. Wild-oxen, aurochs, moose, and stags, roved in great herds, having nothing to fear but carnivora, especially bears and wolves. Men increasing in numbers changed the condition of the region; the animals were driven closer, and several of the more remarkable species, being easy to reach and attack, soon disappeared. The blind cupidity and love of destruction that possess uncivilized races have caused the loss of animals that might have been useful and valuable to man.

In spite of all this, the number of mammals entirely destroyed since the last important changes that have occurred in the climates of Europe is inconsiderable. It is now proved that man was already in existence during the epoch in which elephants clothed with a thick fleece, the rhinoceros, the cave bear and hyena, lived in our countries, and the reindeer was scattered over the land in abundance. Thousands of bones, collected side by side with wrought articles, have given incontestable proofs of this; but the disappearance of elephants and that of several other species must be attributed chiefly to natural causes, and with those we have no concern at present, even when speaking of a partial destruction. In fact, various animals, extinct in some parts of the world, under the influence of atmospheric conditions, have maintained an existence in regions subjected to a climate adapted to them. The reindeer, which was distributed through an immense geographical range in the glacial period, is the most striking instance of this.

A very large mammal, whose existence is not preserved by any tradition, must nevertheless have been among those exterminated by man; that is, the great-horned stag, also called the Irish fossil elk, an animal of the size of the ordinary elk, with the general form of the stag, and enormous horns attaining a spread of more than nine feet. Relics of this magnificent elk have been found in the boggy lands of France, England, Italy, Germany, and Poland. But the remains of this superb animal are chiefly found in Ireland, under those peat-beds which, in all probability, were formed at no very remote period.

Judging from that circumstance, naturalists are inclined to think that the great-horned elk must have long survived the extinction of the great pachyderms. Of late years bones of this species have been found in such quantities as to allow the construction of entire skeletons.

If the existence of the Irish elk is too much a thing of the past to have received historic mention, the case is otherwise with the great wild-ox of Europe (*Bos primigenius* of naturalists), an animal whose size surpassed by a third that of our domestic oxen. This ruminant has left abundant remains in the bottoms of water-courses, in alluvials, peat-bogs, and caves. Like the bison which still survives, it inhabited the forests of Central Europe less than 1,000 years ago. The fact is proved by the writings of old authors. Cæsar was not acquainted with the bison, but he describes with vivid touches the wild-oxen of the Hercynian forest, which he calls by the name of the urus. "They have," says the Roman conqueror, "a stature little below that of elephants; in appearance, color, and form, they are like bulls. Of great swiftness and extremely powerful, they spare neither men nor beasts when seen. They are taken in trenches skillfully prepared. The youths fit themselves to endure fatigue by the practice of hunting these animals. Those who kill many of them display their horns publicly in proof, and receive great applause. The urus can neither be tamed nor accustomed to the sight of man, even though taken very young. The horns of these animals differ much from those of our oxen, in size, shape, and appearance. They are much sought after by the natives, who decorate the edges with a silver circlet, and use them for goblets at great feasts."

The two bovine species of ancient Europe are plainly designated in Seneca's verses: wild-oxen, with great horns, and bisons, with shaggy backs. Pliny makes the same distinction between the wild-oxen of Germany, bisons having a mane, and the urus remarkable for strength and swiftness, to which the name of *bubalus* is commonly wrongly given. That name really belongs to the buffalo (*Bos bubalus*), an animal native to Asia, and long ago well known to the Greeks; but it is generally used in the middle ages to denote the *urus* of Cæsar. The species had not disappeared from the forests of the Vosges and Ardennes during the first centuries of the French monarchy, for Gregory of Tours relates that, by order of King Gontran, a chamberlain, his nephew, and a forest-keeper, were put to death, for having killed a "bubal" in a royal forest situated in the Vosges. Besides, Venuntius Fortunatus, the poet, bishop of Poitiers in 599, mentions in his verses the bubal among the animals hunted in Ardennes and the Vosges by Gogoor, the first mayor of the palace of Austrasia, mentioned in history. The existence together in the Central European forests of the two ruminants mentioned by Latin authors is once more attested by a passage in the famous poem of the "Nibelungen." It is the description of a magnificent hunt; the Burgunds dwell on the banks of the

Rhine, and their king, Gunther, leads Siegfried the Strong, the hero of the poem, into the forest of Odenwald, where dwell bears, elks, wild-boars, stags, and oxen. Siegfried distinguishes himself among all his comrades by killing a great number of wild beasts, and among others a bison and four urus. According to Eckhart, the learned Benedictine, the great ox or bubal was still existing in the Hyrcanian forest in Charlemagne's time, and certainly in some parts of Helvetia. A proof of the latter point is given by the catalogue of meats in use among the good monks of Saint-Gall; the urus, or bubal, and the bison both appear on the list.

Thus it is impossible to doubt that two wild bovine species were living in Europe till the eleventh century; but, dating from that epoch, nothing more is said of the great-horned ox, the urus of Cæsar, the bubal of common people. The utter silence of all writers shows that the destruction of the species was complete. One of the finest animals in the world had become extinct.

Very soon after naturalists had begun to search for the remains of animals belonging to ancient geological periods, they dug up bones of a huge ox, with remains of the core of horns of surprising size. Whole heads and different parts of skeletons were found in rivers, marshes, peat-bogs, in the north and east of France, in England, Germany, and Italy. After careful examination, Cuvier did not hesitate to recognize in these bones the relics of the urus of the ancients; the fact was put beyond doubt by comparison of texts, and studies of the characteristics known to osteology. But that illustrious zoologist, in regarding as the primitive stock of our domestic species that great wild-ox described by Cæsar and hunted by Charlemagne's contemporaries, fell into an error that is now fully admitted. Our oxen came from Asia; in spite of conditions very favorable to bodily development, they retain a size far less than that of the wild species, and are distinguished from them by several marks, particularly by the curve of the horns. Multiplying freely for three centuries in the pampas of South America, they show no tendency to take the dimensions or other characteristics of the urus, which, moreover, was never subdued to the yoke by man.

At a later date than that of Cuvier's writings, a professor of Wilna, Bojardus, obtained an almost perfect skeleton of the great ox of the ancient Gallic and German forests, and, supposing the species to be fossil, he gave it the name, which is now generally used, of *Bos primigenius*. Of very late years, fortunate discoveries encouraged the hope of success in reconstructing the history of humanity previous to historic times, with the aid of materials obtained by excavation. Researches carried on with extreme ardor have collected a vast number of objects that throw an entirely new light on the life of men and animals in the epoch called prehistoric. Remains of the *Bos primigenius* have been discovered in great quantities in grottoes, sandy deposits, and alluvial soil; and some have been obtained from the lake habitations of Lake Constance, where they have been made into utensils. By this means every thing relating to the great-horned wild-ox has become thoroughly known. The *Bos primigenius* is no other than the urus of Cæsar, Seneca, and Pliny, the *bubalus* of Fortunatus and Gregory of Tours, a species contemporaneous with the great pachyderms and great carnivora extinct long before historic times, but which continued to live amid the forests of Central Europe until completely exterminated by men, only eight or ten centuries ago.

The bison of the ancients, now called the aurochs, is not entirely destroyed, though its early complete disappearance is threatened. It yet lives in the condition of a zoological specimen, and there have been opportunities of late of seeing it in some menageries. Formerly it was spread over the greater part of Europe, but it has only been found in certain regions since the historic period began. Aristotle mentions it under the name of *bonasus*, as an animal of Pœonia, that is, of the part of Thrace which is now Bulgaria, and gives a tolerably exact description of it. That which particularly strikes the Greek author in the bonasus is its body, larger than that of the common ox, the mane covering its nape to the shoulders and falling over its eyes, and the woolly hair, of a reddish gray on the lower parts; marks which agree only with those of the bison. Oppian and Pausanias, as well as Seneca and Pliny, speak of the bison, so easily recognized by his heavy neck and shoulders, rounded forehead, shaggy back, and long legs. It was supposed that the aurochs had already disappeared from Gaul at the time of the Roman invasion, because Cæsar makes no mention of it. The proof is imperfect, and it cannot be doubted that the bison was still existing, several centuries later, together with the great wild-ox, at least in Ardennes and the Vosges. It seems to have maintained itself much later in the great Hercynian forest, which stretched from the Rhine to the Danube; but, since a date that cannot be exactly fixed, it has ceased to inhabit the eastern parts of Europe. In our time there remain only a few pairs in Lithuania, in the forest of Bialovicza and in the Caucasus. In the latter country it would appear that the aurochs is now quite rare, for Prof. Brandt, of St. Petersburg, the *savant* who has given most study to the mammals of Russia, had fears that the disappearance of this fine animal was complete; but he learned that they were still to be met with in a locality called Rudeln. More recently we have been informed that a small herd of some fifty animals was known to exist near the village of Atzikhar, on the upper Ouroup. Not a solitary one would remain either in Lithuania or the Caucasus, did not the Russian law forbid taking or killing an aurochs without imperial permission, under pain of death.

The elk, the stag, the chamois, and the wild-goat, still belong to the European fauna; but, unless measures are taken to check the destruction of these mammals, very few centuries will pass before their complete extermination.

Every one who visits a museum of natural history experiences surprise at sight of the moose, a kind of enormous deer. A clumsy form, long legs, a thick muzzle, an extremely short neck, a tuft on the withers, a dewlap fringed with hair under the throat, give the animal an extraordinary appearance, which, in the male, is heightened by huge horns, flattened and serrated on the outer edge. The moose inhabits the marshy forests of the northern parts of Europe and America; it is affirmed that it may still be found at some points in eastern Germany, and it is chiefly met with in Sweden and Norway, Lithuania, the north of Russia, Siberia, and Tartary. It was formerly spread over all Germany, as the hunts of the middle ages preserved in narratives prove. For the authors of the seventeenth or eighteenth century the moose continues a tolerably common species in Poland and Sweden, but is rare for the moderns. Though become quite uncommon in Europe within a hundred years, it continued very abundant at the same period in the Northern United States of America; but every winter it is more eagerly pursued, and this fine animal has ceased to be reckoned among the resources of food for the inhabitants.

In early days our European deer roved everywhere in herds under the great forests, and now scarcely any of them exist in France, except in particularly well-protected forests, where they may be counted by single specimens. Every one has heard retired hunters say again and again, in speaking of deer, "Very soon there will be no more of them." The smaller ruminants, that delight in the cliffs of the highest mountains, and the neighborhood of glaciers, are spared as little. The destruction of the chamois and wild-goat is going on with lamentable rapidity, and it is completed with no other object than the desire of exhibiting skill. The mountaineer is proud of having killed a chamois, and if he kills several he thinks himself a personage deserving admiration. Go to Switzerland, and they will show you, in a hundred places, some part of the mountains where herds of chamois were formerly seen, and you will hear it almost uniformly declared that now there are very few of them, or none at all, left. Go to the Pyrenees; in that region, where the chamois is called the isar, they will tell you that the isar is now exceedingly rare. The chamois, the single European representative of the antelope group, being found scattered over all the great mountains of Europe, will doubtless long maintain itself against the unceasing pursuit of hunters; but the pretty wild-goat of the Alps, once very widely spread, no longer exists, except in a very confined part of the Piedmontese Alps, and perhaps in some nook of Mont Blanc. The chamois and goat, agile animals frequenting most inaccessible regions, swift to fly at the approach of danger, often escaped the hunter's aim when the weapon carried no great distance; long-range guns have become the scourge of Alpine animals.

Thus, within historic times, the *Bos primigenius*, the huge, great-horned ox of Gaul and Germany, has been exterminated. The bison, the largest of mammals in modern Europe, is on the point of disappearing. The other wild ruminants are threatened with more or less remote extinction, and the local authorities in each country hardly understand the importance of checking a deplorable mischief which will soon be beyond remedy.

The history of the beaver is too well known to be repeated at length. A mammal of the highest interest from its habits, valuable for the products it yielded to commerce and manufactures, the beaver, the largest of our rodents, was abundant in France and a great part of Europe, down to the middle ages. In our day, its existence is almost questionable. For several centuries they have been seen only on the banks of the Rhone, or some affluent of that great river, and the few individuals observed in their solitude, far from being objects of special protection, have always been killed. It seems that quite lately a little family of beavers was discovered on an island of the Rhone; it was a piece of good luck, bringing the hope of seeing a nearly extinct species revive again in the country. They were all destroyed without mercy; such a piece of stupidity is possible among civilized people, when those who commit it do not even understand the wrong they are doing. At present beavers are hardly more common in the other parts of Europe than they are in France, and everywhere their buried bones, in mud and peat-bogs, remain the witness of those associations which were the wonder of animal life. In Canada, beavers almost identical with those of Europe were still quite generally found at no very remote time; but they have become extremely rare. Their destruction has been brought about very rapidly, through the cupidity of those great companies formed in North America in the last century for trading in furs.

Extermination, pursued in a senseless fashion, has not only fallen upon land mammals, but has been carried on as to marine species with even greater fury. The large animals of the sea gave rise to active industry and important commerce; but selfishness, and the love of gain, which forget the future in the present, have dried up that source. A century ago, the whale was the object of most profitable fisheries, and those huge cetacea are now so uncommon that their pursuit is given up by most of the nations that once grew rich by following it. Whalers were not content with the capture of old fish, but took younger ones, of very little value, as well as those full-grown. The satisfaction felt in depriving others of the possibility of a good catch two or three years later was too great to permit the reflection that success would thus soon become impossible for all whalers.

The *rytina*, an herbivorous, cetaceous animal, belonging to the lamantin and dugong group, called sea-cows by the inhabitants of the coasts, was common a few hundred years ago in the latitudes of Behring's Islands. This animal, which attained a length of about sixteen feet, was valuable as a resource for the northern tribes, especially the Esquimaux; the flesh provided very acceptable food, and the skin was of use in making their canoes. The pursuit of the rytina has been followed unceasingly, without the least restraint, and these useful cetacea entirely destroyed; the last living one was taken in 1768.

The rytina, covered with a bare skin, black in color, and wrinkled like the bark of an oak, had a mustache with hairs as thick as the quill of a pigeon's feather. These harmless animals delighted in herding together, young and old mingled, and a male and female were often seen moving about together, accompanied by their young family. The rytina usually haunted rather shallow, sandy places, particularly near rivers. They fed on various marine plants, showing a preference, however, for a particular kind of sea-weed. The animals were often seen browsing as they swam slowly, or walked along the bottom, stepping leisurely, like cattle in the fields, and, when satisfied, coming to the shore to lie on their backs. Sometimes in the winter they would be caught and confined under the ice, and die for want of air, their bodies afterward washing ashore. This explains the ease with which, even now, great quantities of the bones of these herbivorous cetacea of Behring's Islands are collected. All that we know of this animal's history has been handed down to us by the memoir of a naturalist and physician, Steller, published in 1751. He accompanied Behring on his voyage to the northwest of America. After the wreck of the ship, followed by the death of the commander and the greater part of his crew, Steller remained on the islands, to which he gave the name of the Russian navigator, till the sailors escaped from the wreck had built a vessel out of the fragments of the ship, which gave them the means of reaching Kamtchatka. Very lately, Russian zoologists have made all possible efforts to rediscover Steller's rytina, but all the labor of their researches has been fruitless. They have only succeeded in procuring some of the animal's bones, and in 1861 the *savants* of St. Petersburg, Moscow, and Helsingfors, had the satisfaction of receiving almost entire skeletons, sent to the governor of the Russian-American possessions, which gave an opportunity for important studies on the osteology of this singular cetacean by Brandt and Nordmann.

II.

The losses suffered by birds have been different, and far more serious than those of mammals; various species, highly remarkable either for great size, or for almost exceptional peculiarities in conformation, have completely disappeared. As to some, the fact is certain, and the presumption is strong as to others. Incapable of flight, and confined to islands, these birds could not escape the attacks of men, and men have exterminated them.

When Pedro de Mascarenhas discovered the islands of the Indian Ocean, in the early years of the sixteenth century, Mauritius, Rodriguez, Bourbon, formerly St. Appolonia, and now Reunion Island, which were called, after the name of the Portuguese navigator, the Mascarene Islands, these regions, covered with rich vegetation, were inhabited by birds in great numbers. Besides species belonging to groups represented in other parts of the world, as parrots, sparrows, pigeons, ducks, there were living some species which excited the astonishment of the navigators by their really extraordinary appearance. There were the *dronte*, or dodo, and the hermit-bird, which have furnished modern authors the theme for numberless writings. Naturalists long cherished the hope of finding again, at some point of the globe, those strange creatures which had no near relationship with any other living being; but the most zealous research has been fruitless, and the hope is abandoned. Many efforts have been made, with the aid of some remains, and a few imperfect sketches, to reconstruct those strange, extinct birds in a scientific way, without any early satisfactory results. Lately, the bones of these vanished species, gathered in tolerably large quantities, either at Rodriguez, or from a marsh in Mauritius, have enabled us to gain clearer ideas of them.

The dodo exceeded the swan in size, and presented the most extraordinary appearance. It had a massive body, supported on thick, short legs, like pillars, a swollen neck, a round head set off by a fringe of feathers brought forward over the face like a hood, great black eyes, ringed with white, and a huge bill, of which the two mandibles, rounded and broad at the end, and terminating in a point in the other direction, have been compared to two spoons laid with the hollow of the bowls against each other. The dodo had wings; but these wings, quite small, mere elements of wings, could be used for nothing; it had a tail, but the tail was reduced to a sort of tuft, made of four or five curly feathers. Then it had silky plumage of a gray color, lighter on the lower parts than on the back, and shaded with yellow on the wings and tail. The animal, absolutely ugly, clumsy, and stupid in its look, inspired repugnance. Buffon, who spoke of it as we do, from sketches and descriptions given by ancient observers, says, that it would be taken for a turtle muffled in a bird's skin.

The earliest notices of the natural productions of Mauritius Island come to us from a voyage made by the Dutch, in 1598. Cornelius Van Neck, the leader of the expedition, finding the island uninhabited, took possession of it, and traveled through the country with his companions, and in the account of his voyage he notes the most remarkable animals and vegetables that were met with on the island. He speaks of the dodo, described as a *Walgvogel*, "a disgusting bird." The animal, represented by a rather coarsely-executed picture, is described in simple terms, of which this passage will give some idea. "It is a bird," the narrator says, "which we called the disgusting bird, the size of a swan, has a round tail, covered with two or three curly tufts, has no wings, but instead of them there are three or four black tufts: of these birds we caught a certain number. . . . We cooked the bird; it was so leathery that we could not boil it enough, but we ate it half raw."

In 1601 two Dutch squadrons, one commanded by Hovmansz, the other by Van Heemskerk, sailed together from the East Indies on their return to Europe. The vessels soon parted, those of Heemskerk anchored at the island of Mauritius, and this time the crews found the dodo remarkably good eating. They probably understood better than Van Neck's men how to prepare them, and those they killed were perhaps fatter or younger. They ate a great number, and salted others down for the remainder of their voyage. Other birds abounded in the island, but were less easily caught than the great dodos, which had no power to fly, and no other means of defense than their huge bills. In the years following, Dutch navigators often landed at the Mauritius, and the dodos, killed with clubs by the sailors, always furnished a large part of the crews' provision; they worked zealously for the destruction of the poor birds, unable to escape pursuit. The Englishman, Sir Thomas Herbert, visiting the island in 1627, found the dodo still there; and Francis Cauche, a French sailor, author of the narrative of a voyage to Madagascar, touching at Mauritius in 1638, also saw there the dodo, or, as he called it, the nazar-bird, which builds its nest from a heap of grasses, on the ground. About the same date, a living dodo was exhibited in London: fortunately, artists took the opportunity to draw from nature the likeness of this strange bird, and the Dutch painter, Roelandt Savery, in particular, depicted it under various aspects. In this way the general appearance of this extinct species has been preserved for us. After the death of the one brought alive to England, it was stuffed, and at last found a place in the museum founded at Oxford by Ashmole.

Up to 1644 Mauritius Island, pretty frequently visited by navigators, had remained unpeopled; but in that year the Dutch founded a colony in it. Such an establishment of course brought about the extinction of the dodo, in which the dogs, cats, and pigs, introduced into the country, no doubt did their part by eating the young and the eggs. The last evidence of the dodo's existence dates in 1681; it is given by the log of an English sailor named Harry, aboard a vessel that wintered at Mauritius, homeward bound from India. In this document, preserved among the manuscripts of the British Museum, the dodo is mentioned as having very tough flesh. And here the first part of the strange creature's history ends.

In 1693 the French naturalist Leguat pursued for several months an exploration of Mauritius Island. He describes a number of animals seen in the country, but he neither met with the dodo, nor did any one speak of it to him. The bird was extinct, and all attempts to find it vain; far less than a century had sufficed for the destruction of a species once abundant at one point on the globe.

At the period the dodo lived in, the natural sciences were very little advanced, and the animal was not the subject of any serious study. Long afterward, zoologists continuing to be struck with the unusual interest attaching to this extinct bird, which was quite unique in creation, felt a laudable desire to complete the imperfections left by ancient accounts of it; but the materials remaining to throw light on the subject were very scanty. The stuffed specimen that had figured in the Oxford Museum had been sacrificed in 1755. The vice-chancellor of the university, and the other commissioners charged by Ashmole with the care of preserving the treasures he had collected, came at an unfortunate hour, as the excellent Strickland says, on their yearly visit to the museum. The poor specimen, more than a century old and doubtless much dilapidated, yet invaluable as the last of the dodos, was committed to the flames by order of the intelligent managers. By good luck, again, they preserved the head and one foot of the animal; scientific interest had nothing to do with the rescue; it was what the world calls an act of good administration.

When modern zoologists undertook to examine the characteristics and natural affinities of the dodo, the relics saved consisted only of the head and foot existing in the Oxford Museum, a foot in the collection of the British Museum at London, a head at Copenhagen forgotten for two hundred years and found again by chance, and a beak at Prague, more recently recovered.

These wretched remnants and the sketches already mentioned, when examined and compared from different points of view, opened a field for dissensions. A single fact was patent to all eyes, the very peculiar, very abnormal character of the dodo. Naturalists, as is usually the case, at first struck by peculiarities of a secondary order, marks of adaptation to a special kind of life, gave their most particular attention to the rudimentary state of the wings in the bird of Mauritius Island. A similar condition of the organs of flight existing in ostriches, and cassowaries, the idea of a more or less close relation between the dodo and those birds suggested itself. Dwelling on a consideration of the same kind, a resemblance was found to penguins and auks, with no greater reasonableness. Prof. de Blainville, paying more regard to the shape of the bill than any thing else, saw in the dodo a representative of the vulture group. Yet a bird of prey incapable of flight, unable to pursue its victims, might seem to us a very extraordinary creature; it must be supposed in such a case that snails, insects, and worms, were the animal's usual food, the resource of dead bodies having scarcely any existence in a region without mammals, like the Mascarene Islands. It has been supposed that the dodo had affinities with the gallinaceous tribes, that is with cocks, Guinea-fowl, turkeys, and some stilt-birds, and that it represented an intermediate type between different families in the class of birds; in a word every supposition was adopted without approaching the truth, so long as the examination was insufficient. Reinhardt, after carefully examining the dodo's skull preserved in the Copenhagen Museum, thought he discovered characteristics pointing out a zoological relation beteen the bird of Mauritius and pigeons. A few years later, a great step toward a solution was made. Strickland, availing himself to the utmost of all procurable materials, published in 1848 an important work on the dodo. The fragments we have noted as existing in the Oxford Museum, a head and a foot, had been stripped of integuments, so as to allow the study of the bony parts; a singular pigeon, the *didunculus*, having a large curved bill, slightly-developed wings, and feet well formed for walking, had been discovered in the Samoa Island by an American *savant.* This pigeon, recalling slightly the marks and habits of the dodo, notwithstanding its small size, furnished a new and most valuable term of comparison. Strickland succeeded in this way in proving that the dodo approached very remarkably the family of Columbids, that is, of pigeons.

After the researches of that able naturalist, no more light could be expected with regard to the famous bird formerly hunted out of existence by the Dutch sailors, without some important discovery. Such a one has quite lately been made in Mauritius Island. In draining a small marsh, poetically called Dream Swamp, George Clark discovered a quantity of dodos' bones. These remains, sent to England and very soon distributed throughout France, quickly attracted attentive study; they permitted the almost complete reconstruction of the skeleton, and in the present state of science all imaginable means of comparison were at hand. Several zoologists gladly profited by these advantages. Alphonse Milne-Edwards, thoroughly familiar with the osteological characteristics of birds, entered actively on the investigation, and we think has succeeded in determining precisely the natural affinities of this singular bird. Recognizing, with Strickland, the very close relations connecting the dodo with pigeons, Edwards concludes that the bird of Mauritius is the type of a special family. Thus the fragments of the history of this strangely annihilated being have been successively brought together, but the complete account of the species remains beyond the possibility of discovery.

Till the seventeenth century the Mascarene Islands were inhabited by many other birds of which the memory has been handed down to us by the merely superficial accounts of some travelers. These birds, some perfectly unfit for flight, others tolerably well endowed as regards the power of their locomotive organs, but having nothing to fear in the absence of men, lived undisturbed in the unpeopled regions of Rodriguez, Bourbon, and Mauritius. They have been destroyed by the attacks of settlers in a very short lapse of time; and now their bones, still collected in small quantities, are the only vestiges that denote the places shared in possession with other harmless beings. Travelers in old times have spoken of the hermit-bird of Rodriguez, the red hen with a snipe's bill, the giant, the bluebird of Bourbon, the hazel-fowl, and immense water-hens. The destruction of these animals is utter.

Francis Leguat, flying from France with a Protestant party, came in 1691 to the island of Rodriguez, till then unexplored, and lived there two years. The story of our compatriot's "Travels and Adventures" has been published; we find in it the description of the fine bird called by him the hermit (*Pezophaps solitarius*). Of all the birds in Rodriguez Island, Leguat says this is the most remarkable species. The males are variously feathered with gray and brown, with the feet of a turkey, and the bill shaped like the turkey's also, but a little more hooked. They are almost tailless, and their rump is rounded and covered with feathers, higher on the legs than the turkey; they have a straight and rather long neck, a black sparkling eye, and a head without crest or tuft. The female, our traveler says, is admirably beautiful; there are blonds and brunettes among them, marked on the forehead with a stripe like a widow's band, and on the breast with plumage whiter than the rest of the body. They walk with such a mingling of pride and gracefulness that one cannot avoid admiring and loving them, so that their good looks often save their lives. Not a feather lies uneven on their whole body, such pains do they take to smooth and arrange their plumage with their bills. These hermit-birds do not fly; they only use their wings, which are too small to bear the weight of the body, either in fighting or drumming when calling each other. Leguat adds that they are taken with great difficulty in the woods; but in open places it is easy to run them down, as they are not very swift. From March to September they are extremely fat, and the taste, especially of the young ones, excellent. Some among the males are found weighing forty-five pounds. These birds, intending to build a nest, choose a clear spot, collect a few palm-leaves, and raise the structure a foot and a half above the surface; they hatch but one egg at a time, and the male and female sit alternately during seven weeks, the period of incubation, and for some months longer the young bird needs assistance from the old ones. These beautiful birds of Rodriguez, called hermits because they seldom go in flocks, were abundant in the island at the end of the seventeenth century, when the French naturalist expressed such admiration for them. In a few years they have all perished, and nothing but bones crusted with stalagmite permitted us to ascertain that the species described by Leguat was of a kind unknown elsewhere, when an English explorer, Newton, undertook to examine the caves and boggy lands of the small island of Rodriguez. More than two thousand fragments, the last traces of the extinct bird, were collected. The study of these wretched relics was made with the greatest care, and we now know that the hermit-bird represented a special type, having close affinities with the dodo and the pigeon. A singular detail leads us to place full reliance on Leguat's observations. Our traveler had said, in speaking of the males of this Rodriguez bird: "The wing of the pinion thickens at its end, and forms a little round mass like a musket-ball under the feathers; this, with the bill, is the bird's chief defense." This little round mass has been found in the shape of a bony prominence on that part of the limb called the metacarpus.

At the Isle of Bourbon, as at Mauritius and Rodriguez, the first explorers found many birds that were clumsy and unable to fly. A species resembling the dodo, described by Dubois, as also by the Dutch Bontrekoe and the Englishman Castleton, was completely white, like a young lamb. A sketch of this bird has lately been found in an old picture; it is a true white dodo, with a yellow tinge on the wings. A hermit observed by the traveler Carré in 1688, probably quite distinct from the Rodriguez species, was magnificent: "The beauty of its plumage," the account says, "is lovely to behold, being a changeable color verging to yellow." A large bluebird with red beak and feet was in all probability of the group of superb sultan-fowls which zoologists call the porphyrions and notornis. All these birds have completely disappeared.

Several species, now extinct, inhabited Mauritius in particular, as the dodo, less than a century and a half ago. Francis Cauche, as also a Protestant missionary named Hoffman, described "red fowls with snipes' bills" which were taken by hand on offering them a bit of red cloth. It would be hard to determine the species by so vague an indication, but a piece of good fortune lately came to our aid. Some paintings on vellum have been discovered in the private library founded by the Austrian Emperor Francis I.; one represents the dodo, another the snipe-beaked hen. De Frauenfeld has published these drawings, and, greatly struck by the extraordinary peculiarities of the red fowl without wings, he has named for it a genus, *Aphanapteryx*, without, however, succeeding in deciding upon the bird's natural affinities. More fortunate, Milne-Edwards had seen some of the bones taken from the famous Dream Swamp, and he clearly recognized in the *Aphanapteryx* a type of the rail family. With this family, and particularly with the group of the swift-runners, well represented in Australia, the same zoologist, after examining some relics, successfully connected the plump waders, covered with light-gray feathers, which Leguat delighted in during his residence at Rodriguez. The same exact historian of the Mascarene Islands, as they once were, has also drawn the description of a very remarkable bird that haunted the marshes of Mauritius. "Numbers of certain birds are seen," says this traveller, "which they call giants, because their head rises six feet high. They are extremely high on the legs, and have a very long body, no larger than that of a goose. They are entirely white except one slightly red spot under the wing; they have the bill of a goose, but little more pointed, and their toes are very long and somewhat separated. They feed in marshy places, where dogs often surprise them, because they take some time to lift themselves from the ground. We saw one one day at Rodriguez, of such a size that we caught him by hand; this is the only one we observed there, which leads me to think he must have been driven thither by the wind, not being able to resist its force. The bird is tolerably good eating." Much unsuccessful conjecture as to what this "giant" might be was wasted, but at length the able Dutch naturalist Schlegel proved that the species was a kind of water-hen, quite peculiar in character, and in naming it (*Leguatia gigantea*) he meant to perpetuate the memory of the Protestant fugitive whose misfortune became a gain to science.

Nor is this yet all: the bones of a coot much larger than the European one have been found at Mauritius, as well as remains belonging to a parrot, contemporary with the dodo, of the size of a cockatoo; a fragment of another parrot, now extinct, has been found at Rodriguez. We are filled with astonishment in reflecting on what must formerly have been the richness of Nature in the Mascarene Islands; magnificent or wonderful birds were the embellishments of those regions lost as it were in ocean, and amid a world of weaker creatures they seemed to be the sovereigns.

Thirty years ago a discovery of the most unexpected kind produced a real sensation in the scientific world: the bones of birds of gigantic proportions had just been brought to light in the rivers of New Zealand. Nothing more was needed to stimulate men of science, who were exploring the country of the Maoris, with the desire of pushing their researches actively. They excavated in water-courses, marshes, and caves, and bones in considerable quantity were soon found. They obtained the entire skeleton of a bird approaching the giraffe in size, and those of several other species of the same group of smaller dimensions. These remarkable fragments coming into the hands of the eminent English naturalist, Richard Owen, were the subject of continued profound studies. The birds of New Zealand, extinct at an epoch doubtless very near our own, and yet known to us only by relics, have been called the *Dinornis;* the species of largest size has received the name of gigantic dinornis. The English explorers, finding the bones of dinornis in the beds or on the banks of rivers, often mixed with the bones of animals yet living in the country, or with those of man even, sometimes in cavities full of ashes and charcoal, where food had been prepared, were convinced that these relics came from individuals whose destruction was recent. The hope occurred to every one of finding yet living specimens either in the woods or the mountains, encouraging them to scour the country; but all researches till now have remained unsuccessful. The natives of New Zealand, asked a thousand times about the origin of these bones of enormous size found abundantly in so many localities, answered generally that the remains were those of a sort of bird known among them as the *moa*. The Maoris often declared that moas still existed in certain parts of the mountains; several pretended to have seen them, perhaps by way of boasting, for no precise fact occasioned the assertion to be taken as expressing the truth. Still, a vague tradition does seem to have been kept up among the native New-Zealanders with regard to enormous extinct birds.

The dinornis had marked relations with ostriches, and yet more so with cassowaries; in a word, they belonged, at least the greater part of them, to that family of running birds called *Struthionids*. The comparison of bones, rigorously made by Richard Owen, leaves no doubt on this point. New Zealand was formerly inhabited by numerous species of dinornis, perfectly distinct from each other, and varying much in their proportions. The gigantic dinornis we have mentioned might attain the height of more than eleven feet; other species were of the height of an ostrich, or less, and others had a much more massive shape and a slow gait, as is proved in the elephant-footed dinornis (*Emeus elephantopus*) by the thick, stout, enormous leg-bones. Each species inhabited a very limited region; the dinornis of North Island and that of Middle Island were not the same, and many of them seem to have lived in a very narrow space. Incapable of flying or swimming, these animals had very sedentary habits. Though it is proved that the great birds of New Zealand must for the most part present close resemblances to the cassowaries, the fact is less certain for some species.

We have observations, descriptions, and even sketches of the birds of the Mascarene Islands, derived from travelers of more or less learning; vague descriptions indeed, sketches often very imperfect, which yet have become precious. They give us at least a general idea of the look, the gait, the colors and habits of the lost animals. We have nothing like this as to the birds of the Austral Islands; some scattered bones, merely, have enabled us to reconstruct skeletons, and to frame comparisons with the nearest species existing in other countries. If the extinct creature differed but slightly in its forms from a well-known living species, the relations are easily established by that single comparison; the differences appear readily to the eye of a practised naturalist, an almost exact notion of the extinct being is gained, a sort of new life seems given to the creature whose mere relics have been seen. On the contrary, if the animal to be reconstructed had very peculiar characteristics, or in its general form proportions unknown elsewhere, it becomes impossible to reach a satisfactory result. We attempt to call the animated being before us in thought, but reflection tells us that the image cannot be a faithful one. This is probably the case with some of the extinct birds of New Zealand.

The question has been asked whether the hope of finding any living dinornis can be seriously entertained; on this point the affirmative and negative have both been maintained by zoologists, and especially by the explorers of New Zealand, who, better than any one else, can give reasons for their view. Dr. Thomson, who has made a special study of the spots and caves from which an immense number of bones of these great birds has been taken, is convinced that the famous moas of the Maoris were extinct at least two centuries ago, and will be looked for now in vain, and the proofs he brings in support of this opinion are serious enough to inspire fears lest his prophecy be correct. The taking possession of the New-Zealand Islands by the Maoris is generally assigned to the fifteenth century, and in countries not inhabited by mammals the early settlers must have hunted the great birds, that yield immense supplies of food, in an unsparing way. Under such circumstances how could the destruction of the dinornis have failed to be rapid and very quickly effected? Tasman, who discovered New Zealand in 1642, gained no information on the subject of the moas, although this fact is unimportant, since he maintained very slight relations with the natives; but their silence in intercourse with other navigators is more significant. Cook explored the country three times, established communication with the inhabitants, had conversations with the great chief Rauparaha, and thus must have known the popular traditions; yet nothing was ever said of gigantic birds. Dumont d'Urville, a sagacious man, anxious to investigate the life of the tribes he visited, studied the habits and customs of the Maoris; he fixed his attention on the plants and animals of New Zealand, and nothing led him to suspect the existence of the dinornis. According to Dr. Thomson, the native traditions on this subject are absolutely vague, and bear witness merely to the fact that there were moas living at the same time with the men of the race now inhabiting the country. No Maori of this day professes to have seen a moa moving about the woods or the plains. The state of complete preservation in which certain remains have been found must be attributed, the same author believes, merely to the peculiarities of the soil in which they were buried.

Now, those who do not give up the hope of finding some living dinornis, at some time, rely on several indications which perhaps must not be altogether disregarded. The Rev. Mr. Taylor affirms that the Maoris have traditions about the moa-hunts of their ancestors, and songs celebrating the hunters' exploits. Some travelers assert that they have had positive declarations from the natives of the presence of gigantic birds in the mountains; others declare that they have seen moas, but always ran away in terror at the sight of those strange animals; and others still suppose that they have seen tracks on the ground indicating the passage of an enormous bird. It is impossible to put much confidence in such stories, but observations on the condition of certain remains are much more striking. On the 16th of June, 1864, the Linnæan Society of London listened to the reading of a curious memoir by Mr. Allis, on the discovery of a nearly complete skeleton of the dinornis. This skeleton, found by some gold-hunters under a mound of sand near Dunedin, in the province of Otago, was in an astonishing state of preservation. Cartilages, tendons, and ligaments, were still adhering to the bones; a part of the skin, still undestroyed, contained quills of parted feathers like those of the emu, a kind of cassowary; the feather part of some of these remained. A very experienced zoologist judged that the animal had very probably not been dead more than ten or twelve years. A last point for reflection, as to the existence of dinornis at the present day, is given us by a distinguished naval officer, Commander Jouan, who has made a great number of interesting observations during his long voyages. This accomplished navigator tells us that there are solitudes in Middle Island into which the Maoris, and of course Europeans, have never penetrated, and the interior of North Island is little known beyond the valleys, the bottom of which is occupied by water-courses, which allow traveling by canoes, or at most by pirogues. Therefore, great birds might still have safe retreats. If the extinction of the dinornis is not utter, it seems certain at least as to most species of the group.

Other New-Zealand birds of moderate size seem to be threatened in their turn with complete destruction in the near future. The brown-feathered apteryx, with long, curved beak and stout feet, are very much pursued since the colonization. These walking-birds, having their vestiges of wings even smaller than ostriches and cassowaries, unable to escape by swift flight, live on the ground, and merely hide themselves in holes. Dogs trained to pursue them easily make them a prey, and the poor apteryx has already almost vanished from the inhabited country; their destruction will be complete with the advance of colonization. A singular parrot, of the size of a common fowl, the *strigops*, peculiar to New Zealand, formerly quite common, but now extremely rare, is also doomed to perish. The strigops, a true parrot in all characteristics, an owl in its habits, dull in movement and plumage, is the only nocturnal species of the parrot family, and for that reason extremely interesting to zoologists. This bird, light-green in color, streaked with black lines, flies but little; it runs along the ground and takes refuge in holes; the object of constant attack by dogs and men, it exists nowhere but in solitudes as yet inaccessible. The rarity of the native birds becoming every day more marked in New Zealand, many persons have supposed that the rapid disappearance of the most remarkable species might be accounted for by a lowering of the temperature. They have forgotten that the apteryx and the strigops do very well in the present state of the country, wherever they are not disturbed.

Among the creatures whose recent disappearance is very probable without being actually certain, is reckoned a bird of Madagascar, exceeding the gigantic dinornis in size. The first important discovery of remains left by this lost species is quite recent. It was announced to the French Academy of Sciences by Geoffroy Saint-Hilaire, the 27th of January, 1851. Enormous eggs brought to France by Alfred Abadie, captain of a merchantman, excited amazement in every one, *savants* and ignorant alike. These eggs, six times as large as an ostrich's, and equal to 148 hen's-eggs, had a capacity of more than 1¾ gallon. Nothing more astonishing had ever been seen. From a few scattered bits of bones found in the same spot, Saint-Hilaire traced vestiges of the bird to which the eggs must be attributed, and designated the animal by the name of the *Æpyornis maximus.* The island of Madagascar presenting so extended a surface, unexplored in all parts, it was readily believed that the æpyornis might still be wandering over its vast solitudes, for in Madagascar, as in New Zealand, the natives speak of enormous birds as existing in the woods and mountains. Since the last exploration of the great African island, this seems an improbability. An intelligent young naturalist, Grandidier, made a voyage to Madagascar a few years ago; after gaining much information, he returned once more to the region which promised new discoveries. Quite lately, while making excavations in the midst of a marshy tract in Amboulisate, on the west coast of the island, Grandidier had the good fortune to collect some bones that seem to belong to the bird with those incomparable eggs. These fragments, it is true, are nothing more than two vertebræ, a thigh-bone, and a leg-bone; they enabled Milne-Edwards to demonstrate the relationship of the æpyornis with the ostrich, cassowary, and dinornis, and to prove the fact that the Madagascar bird, with a heavier body and stouter legs than any of the dinornis had, yet was not so high in stature as the largest species of New Zealand. Remains of the æpyornis of inferior size found in small quantity disclose, moreover, the existence of several species belonging to the same type, and inhabiting the same region at an area doubtless not very remote.

Every one in France and other parts of Europe is aware of the rapid decrease of birds. The larger kinds will, perhaps, be exterminated before a century passes. The bustard, which, in Buffon's time, was commonly enough found in the plains of Poitou and Champagne, is now extremely rare. The tétras, better known under the name of the great heath-cock, formerly abundant in our forests, is now found only in a few localities. Game so superb offers irresistible temptations to sportsmen.

In past ages the great auks (*Alca impennis*), fitted for swimming, but unable to fly, abounded on the shores of the arctic regions; they have been destroyed, annihilated. At a rather remote period they were common on all the coasts of Scandinavia, as in the Orkney and Faroe islands, and on the banks of Newfoundland; at a date nearer our own, they were still frequently seen in Lapland and Greenland;

in the first years of the present century they only existed in some unfrequented northern islands. For thirty or forty years past, not a single one has been seen anywhere. The great auk figures stuffed in some museums of natural history; it is now an object of priceless value. A bird of the size of a goose, having the upper parts of its body velvet-black, its throat shaded with brown, and its lower parts white, the auk presents zoological marks of peculiar interest; it is intermediate between the lesser auk, a flying bird, which visits our shores in winter, and the penguins of southern lands. The great auk formerly furnished the people of the north with a large part of their food. Steenstrup has found thousands of bones of these birds, gnawed, splintered, and scratched, among the famous refuse-heaps of Denmark and Norway, which he has dug into with great service to information for history. In many places, penguins made the principal food of the ancient Scandinavians; later in time, these birds and their eggs, gathered by thousands in the breaks and crevices of the rocks, were a resource for sailors, and of all that abundance there remains nothing, absolutely nothing. Birds, as we see, have already lost many members of their family.

The destruction of the great animals, effected by men within a few centuries, leads us to anticipate a serious impoverishment of Nature in a more or less remote future. The extinction of a multitude of species has taken place with deplorable rapidity in the Mascarene Islands; it is going on in many other parts of the globe. Singularly, wherever European civilization penetrates, devastation begins, and sooner or later is completed. The most industrious nations are the greatest ravagers. A few thousand years more, and the whole earth will present a uniform and wretched appearance.

The facts we have just recalled, as to beings exterminated by man, lead the mind to reflections on the primitive state of our present world. In the Mascarene Islands, in New Zealand, a special fauna, entirely different from that of the countries nearest them, proves that these islands have remained isolated since the appearance of the animals that inhabit or did till lately inhabit them. The presence of birds unable to fly, or to defend themselves effectually in countries where no dangerous enemies are to be feared, is the indication of a regular assignment of organism to determinate locations, for one who does not believe in indefinite transformations perceptible only to the imagination. Finally, in seeing animals wanting effective means of locomotion established in limited ranges, we are led to believe that each species at first lived only on some very small part of the globe, and that the varying distribution of individuals results chiefly from the enlargement of locomotive powers.

THE MOQUIS INDIANS OF ARIZONA

By Dr. OSCAR LOEW,

CHEMIST TO WHEELER'S SURVEYING EXPEDITION.

AMONG the aboriginal tribes of the Southwest is that of the Moquis, an isolated remnant of a former wide-spread nation. These Indians are of particular interest, especially as a study for the ethnologist, on account of their peculiar manner of living, strange customs, etc., as well as in being little known and seldom visited by the white man.

While the literature of American ethnology teems with interesting accounts of the aboriginal race of this country, and is replete with the history of the various other tribes, but little is said regarding the singular and romantic branch of the Pueblos who call themselves "Moquis." Year after year military expeditions have traversed the far West, yet few have been led to the hidden recesses of this tribe; moreover, theirs is a region seldom visited by civilians, and of these the few coming thither are principally New-Mexicans.

It was the sixth day after leaving Fort Defiance, that our party, under Lieutenant Russell (of the "Expedition for Explorations and Surveys west of the One Hundredth Meridian," in charge of Lieutenant George M. Wheeler, U. S. Engineers), began to near the Moquis villages, concerning the inhabitants of which we had listened to so many thrilling and marvelous stories. Immediately before us was spread a wide, sandy basin, whose loose, dusty surface offered no verdure to delight the eye, or relieve the wearisome monotony of the barren landscape. Ten miles away over this trackless desert loomed up, on the western horizon, wide and precipitous cliffs whose heights it would seem impossible to climb. "On those cliffs," said our Navajo guide, "live the Moquis." A few hours later, and we had crossed the sterile waste, and were at the base of the sandstone masses whose outline we had previously traced in the far distance, there to find perched on lofty summits the habitations of the singular people we had come so far to see.

As we approached, human beings began to throng the rim of the precipitous bluffs, their dusky features betraying curiosity over an event so novel and unexpected as the presence of white men at the very threshold of their citadel. We now began the ascent to the villages; a narrow path led, by a serpentine route, up the dizzy heights, and, in single file, we soon gained the summit; not, however, until we had passed several Moquis posted, sentinel-like, along the approach. Once up the steeps, we were soon surrounded by Indians, when, *nolens volens*, a hearty hand-shaking ensued, and friendly intercourse forthwith began.

The home of the Moquis is on a rocky island, separated from the rest of the world by an ocean of sand, and is one of the strongest natural fortifications; indeed, as a stronghold against invasion, it may justly be termed the Gibraltar of the West. Neither the Navajos nor the Apaches, whose tribes have ever numbered some of the most celebrated of Indian warriors, have as yet met with even temporary success in their attacks on the Moquis. Although for several years past these tribes have been on peaceable terms, there is, nevertheless, no special liking the one for the other, and ever and anon bitter recollections of by-gone strifes are openly manifested, and the younger bucks strip for the war-path.

The Moquis number about 2,500 souls, and occupy seven villages, or, speaking accurately, six, one being inhabited by a branch of the Tehuas. These villages are built on the tops of four sandstone *mesas*,[1] which are separate from each other about eight miles. On the first are three of the villages, fifty yards apart. They are named respectively, Tehua, Tsi-tsumo-vi, and Obiki, the last commonly but erroneously called Hualpy. The villages on the second mesa are Mushangene-vi and Shebaula-vi. On mesa number three is Shongoba-vi, and on number four Orai-vi. These villages occupy the entire width of the mesas, and, standing immediately before the houses, one may look vertically down a frightful depth of three hundred feet! In many places the sides of the mesas are terraced, the terraces being used as sheep-corrals. On the rims of these high and rocky walls children may be seen at play, unconscious of danger, while the mother performs the duties of the household apparently thoughtless of the gulf that yawns within stepping-distance of her innocent brood. Below, on the sheep-terraces, other children are delightfully engaged in sucking goat's milk from its *natural* fountain.

As stated, these villages occupy the entire width of the mesas. The houses are built in a row, side by side, and are principally of two (although not a few are of four) stories. They are constructed in a terrace style, the upper stories being removed a few feet back from the lower ones. The mode of entry is by means of ladders or steps cut in the side-walls. These habitations are not built of adobe, of which material the larger number of Indian and Mexican huts are formed, but of stones firmly held in place by a cement of clay and sand. The several stories are, respectively, about seven feet high, and are divided into a number of rooms, each of which is provided with an open fireplace. For windows the walls are pierced in many places, the holes being cut square, and about a foot either way. In severe winters the inhabitants of these houses shelter themselves in cellars or caves in the rocks near by.

In appearance the Moquis resembles the Caucasian rather than the Mongolian race. The facial features are a cross between pleasant and

[1] *Mesa*, table, a flat surface on the top of hills or mountains.

severe, and in many instances the expression is that of unusual intelligence. The complexion is a light red-brown, the teeth snow-white, and hair "jet-black," coarse and long. Everywhere throughout the tribe the pitted skin is evidence that at no remote period in the past small-pox has held its pernicious sway.

Street in a Moquis Village.

These Indians are well clad, especially the females, some of whom are neatly attired, particularly the daughters of the chief, who, by-the-by, are exceedingly interesting young ladies. Their dress partakes much of that common in the Eastern cities, while the hair is worn in the style known as "Pompadour." One advantage these nymphs of the desert possess over those of the East is, that of being able to carry their head-gear with them when they retire to rest, the whole being the work of Nature in themselves and nothing of art. By reason of the extensive ravages of the small-pox, many of the houses are just now empty, their occupants having fallen victims to a disease whose merciless march they had not the scientific knowledge to stay.

Among the Moquis settlements are found dogs, donkeys, sheep, goats, and chickens, but not a single specimen of the feline tribe, nor a hog, a cow, nor a horse. The donkey is almost indispensable, in that it is their principal means of transporting wood, which has to be brought great distances. In the absence of wood, dried sheep-excrement is extensively used as fuel. Very little grass is to be met with in the vicinity of the mesas, the entire country round about being a vast sand-heap devoid of vegetation. For pasture the sheep are driven off several miles northward to a few patches of poor grass.

The chief article of subsistence of these natives is Indian-corn; they have no meat, excepting occasionally mutton. The sheep are raised for their wool, and not for table-purposes. From the wool they manufacture an extraordinarily good and serviceable blanket.

The atmosphere being very dry, and no rains occurring sometimes for several months, and with no streams near by for irrigating purposes, it may well be inquired how these untutored aborigines, on whom the light of our civilization has not yet dawned, manage to produce the article which furnishes them with the staff of life. The method employed is as follows: The seed is planted at from one to two feet beneath the sand and very wide apart. At this depth they have found by experience that there is sufficient moisture to develop and sustain the plant. On analyzing specimens of the soil, the chemist of the expedition has found that the experience of these untaught Indians is in full accord with the results of his investigations. The interesting fact was elucidated that subsoil at a distance of one foot contains two and two-tenths per cent. of moisture to one per cent. at the surface, from which it may be inferred with reason, that at no great depth there must be a stratum of water. This water, ascending by capillary attraction, is rapidly evaporated as soon as it reaches the surface, on account of the looseness of the soil and the arid atmosphere. Grass-seed scattered over the ground in this region of sand would fail to germinate, and only be wasted. The only water in this locality is that supplied by several small springs at the bases of the mesas.

The bread made by the Moquis has a similarity to our "wafer." In preparing it the corn is ground between two stones to a fine powder, water being subsequently added until the mixture is brought to a thin paste. This paste is spread out with the hand in layers over a hot stone, and in a few moments is ready for eating. Another variety of their food is prepared from corn that has been germinated, whereby, as is well known, a saccharine matter is developed and a species of malt produced; this food they call *panoche.* Still a third kind is derived by mixing flour and dried meat in a powdered state: this they call *tomales.*

The Moquis have one school, which is provided them by the "great father," and which is attended by children from three to five years old. On being examined, these little ones counted correctly to 100. They are quite proficient in spelling, while their ready recital, without the book, of numerous English verses, showed them possessed of very retentive memories.

As previously mentioned, the Tehuas occupy one of the Moquis villages. The languages of the two tribes, however, are quite different, that of the latter being unintelligible to the former. On collecting a vocabulary of the language of the Tehuas, it was found to be identical with that of the Indians of Ildefonso, who inhabit some twenty-five miles west of Santa Fé, and from three to four hundred miles distant from the Moquis towns. Inquiry as to the date of settlement of the Tehuas with the Moquis proved fruitless of the desired result; the Indians either did not know, or were unwilling to tell. One intelligent Moquis, named Mesayamtiba, who answered many questions readily and very intelligibly, estimated the period of intermingling of the two tribes at upward of one hundred years.

As a refutation of the rather prevalent notion that Indian languages are subject to rapid change, it may be said that, although the Tehuas and Ildefonsos have been separated at least a century, and that, too, at a distance from each other of several hundred miles, the language of the branch tribe is still identical with that of the parent stem. Furthermore, although the Tehuas and Moquis live but fifty yards apart, their dialects are entirely different, that of the former not embracing a single word used by the latter. By this, however, it is not to be understood that some of the Moquis do not understand the Tehuas language, and *vice versa.* Besides their own language, a few of both tribes speak broken Spanish.

With regard to the religion of the Moquis, diligent investigation failed to develop any thing definite. To the inquiry whether they worship Montezuma, the reply was, in broken Spanish, "*No sabe*" ("I don't know"). By Mesayamtiba, we were informed that he believed the "sun to be the true God," but that the so-called "happy hunting-ground" was, in his opinion, but a creation of the imagination—the "baseless fabric of a dream." They have neither church nor other place of worship to be found, which is evidence that the Spanish Jesuits have been unable to gain a foothold among them, although these priests have succeeded in establishing themselves with almost all the other Pueblo tribes, as is plainly shown by the ruins of Jesuit churches in Acoma, Gemez, and other towns. The Moquis sometimes hold religious meetings in caves in the vicinity of their settlements. On being asked to decipher an hieroglyphical inscription some fifteen miles southeast from their villages, a copy of which was shown them, they appeared unable to do so, replying, "*No sabe.*" The belief is well entertained, however, that they were acquainted with the inscription, and knew its hidden meaning, since there were found in the house of one of the chiefs figures carved in wood which corresponded exactly to some of those employed in the inscription. If these were designed as objects of worship, no profound veneration was manifested for them, since they were readily parted with for a trifling quantity of tobacco.

The exact date at which this singular people settled in Northeastern Arizona, and built their habitations on massive rocks, whose foundations are far beneath the level of the sandy plain which surrounds them, is a question still enveloped in mystery. Taking into consideration the fact that the space between the several villages on one of the mesas is solid rock, and that across this space a path has been worn by human feet to a depth of several inches, and remembering that the shoes of the people who have trod out this stony pathway have been of the softest leather, it is not unreasonable to assume that at least a thousand years have elapsed since this tribe first made its appearance in this bleak and uninviting section of the Western World.

While our visit to the Moquis resulted in much valuable information concerning this remnant of a race fast disappearing from the face of the earth, we were otherwise well repaid for the hardships we had encountered in reaching this isolated spot, and shall not soon forget the pleasant hours spent in the company of these half-civilized beings. As evening drew near, sitting on the tops of the lofty mesas, our fevered brows were gently fanned by cooling breezes, which soon caused us to forget the tropical heat of the day, while our eyes were feasted by a sunset seldom equaled in grandeur and sublimity. The sinking sun produced a golden hue around the summits of the far-distant Sierra de San Francisco, while its light, reflected along the horizon, transformed the sky into an ocean of blood. It was long after nightfall ere wearied nature sought repose; but, at last, we retired to rest, with naught but rock for our pillow, and with no roof above us save the blue canopy of Nature, which seemed more than ever fretted with twinkling stars.

MENTAL EVOLUTION AND NECESSARY TRUTHS.[1]

By HERBERT SPENCER.

I AM not about to continue a controversy which I regret having been provoked into by the misrepresentations of one who ignored the contents of works he professed to review. Reply and rejoinder may go on endlessly. I could not, to much purpose, argue with Mr. Hayward, who, instead of taking such unconsciously-formed preconceptions as those resulting from the infinite experiences of muscular tensions and their effects, proposes to exemplify unconsciously-formed preconceptions by a consciously-formed hypothesis concerning the relation between weight and motion. Nor should I care to discuss any question with my new anonymous assailant; who, when certain examples given show the "exact quantitative relations" spoken of to be those of direct proportion, describes me as "intensely unmathematical" because I subsequently use the more general expression as equivalent to the more special—which, in the case in question, it is.

The first of my objects in now writing is to remind "some by-standers, who may from their antecedents be presumed competent to judge," that the essential question is not a mathematical one, but a logical and psychological one, in respect of which I am not aware that senior wranglers, as such, can claim any special competence. Further, even admitting the assumption that the question is mathematical, I have to warn the reader that he will be much misled if he infers that there are not "some by-standers who may from their antecedents be presumed" *more* "competent to judge," who concur in the opinion that the laws of motion cannot be demonstrated experimentally.

My second object is to inclose, for publication in *Nature*, a passage now standing in type to be added to future impressions of "First Principles" in further elucidation of necessary truths, and our apprehensions of them:

"The consciousness of logical necessity is the consciousness that a certain conclusion is implicitly contained in certain premises explicitly stated. If, contrasting a young child and an adult, we see that this consciousness of logical necessity, absent from the one, is present in the other, we are taught that there is a *growing up* to the recognition

[1] [The article published last month, to which we gave the title of "Punishing a Senior Wrangler," was issued by Mr. Spencer in a pamphlet as a part of his "Replies to Criticism." It led to a running fight in the columns of *Nature*, which we have not printed. A second "Senior Wrangler" having come to the rescue of the first, with assurances of his "sympathy," and R. B. Hayward having pitched in, Mr. Spencer sends the above communication to *Nature*, which we reproduce, because of the permanent interest of his argument.—Ed.]

of necessary truth, merely by the unfolding of the inherited intellectual forms and faculties.

"To state the case more specifically: Before a necessary truth can be known as such, two conditions must be fulfilled. There must be a mental structure capable of grasping the terms of the proposition and the relation alleged between them; and there must be such definite deliberate mental representation of these terms as makes possible a clear consciousness of this relation. Non-fulfillment of either condition may cause non-recognition of the necessity of the truth; and may even lead to acceptance of its contrary as true. Let us take cases.

"The savage who cannot count the fingers on one hand, can frame no definite thought answering to the statement that 7 and 5 make 12; still less can he frame the consciousness that no other total is possible.

"The boy adding up figures inattentively, says to himself that 7 and 5 make 11; and may repeatedly bring out a wrong result by repeatedly making this error.

"Neither the non-recognition of the truth that 7 and 5 make 12, which in the savage results from undeveloped mental structure, nor the assertion, due to the boy's careless mental action, that they make 11, leads us to doubt the necessity of the relation between these two separately-existing numbers, and the sum they make when existing together. Nor does failure from either cause to apprehend the necessity of this relation make us hesitate to say that, when its terms are distinctly represented in thought, its necessity will be seen; and that, apart from any multiplied experiences, this necessity becomes cognizable when structures and functions are so far developed that groups of 7 and 5 and 12 can be intellectually grasped.

"Manifestly, then, there is a recognition of necessary truths, as such, which accompanies mental evolution. Along with acquirement of more complex faculty and more vivid imagination, there comes a power of perceiving to be necessary truths what were before not recognized as truths at all. And there are ascending gradations in these recognitions. Thus a boy who has intelligence enough to see that things which are equal to the same thing are equal to one another, may be unable to see that ratios which are severally equal to certain other ratios, that are unequal to each other, are themselves unequal; though to a more developed mind this last axiom is no less obviously necessary than the first.

"All this, which holds of logical and mathematical truths, holds, with change of terms, of physical truths. There are necessary truths in Physics, for the apprehension of which, also, a developed and disciplined intelligence is required; and, before such intelligence arises, not only may there be failure to apprehend the necessity of them, but there may be vague beliefs in their contraries. Up to comparatively recent times, all mankind were in this state of incapacity with respect to physical axioms; and the mass of mankind are so still. Various popular notions betray inability to form clear ideas of forces and their relations, or carelessness in thinking, or both. Effects are expected without causes of fit kinds; or effects extremely disproportionate to causes are looked for; or causes are supposed to end without effects. But though many are thus incapable of grasping physical axioms, it no more follows that physical axioms are not knowable *a priori* by a developed intelligence, than it follows that there is no necessity in logical relations because many have intellects not developed enough to perceive the necessity.

"The ultimate physical truth of which clear apprehension is eventually reached is, that force can neither arise without an equivalent antecedent, nor disappear without an equivalent consequent. Along with power of introspection there comes recognition of the fact that existence cannot be conceived as beginning or ending: the Laws of Thought themselves negative any such mental representation. And if it be asked why this intuition, which all physical axioms indirectly imply, and which is postulate in every physical experiment, is to be taken as authoritative because its negation is inconceivable, the answer is that no argument which sets out to discredit it can do this without logical suicide; since there is no other warrant for asserting the dependence of any conclusion on its premises than the inconceivability of its negation."

This passage forms part of a revised version of the chapters on Matter, Motion, and Force, which I have contemplated making for this year past. When those chapters were written and stereotyped, in April, 1861 (*see* Preface), the modern doctrines concerning Force and its transformation were so imperfectly developed, that some of the leading technical words now currently used were not introduced. The reorganization of "First Principles," which I made in 1867, for the purpose of more truly presenting the general Theory of Evolution, did not implicate these chapters, and I believe I did not even re-read them: the stereotype plates, in common with those of many other chapters, with the numberings of pages and sections altered, were used afresh, and continue still to stand as they originally did. But while now rectifying defects of statement which it was scarcely possible to avoid thirteen years ago, I find no reason for changing the essential conception set forth in those chapters; nor is the need for changing it suggested to me by those on whose judgments I have the best reasons for relying.

SKETCH OF DR. THOMAS YOUNG.

ON a slab in Westminster Abbey, surmounted by a profile medallion, the work of Chantrey, there is the following inscription:

SACRED TO THE MEMORY OF
THOMAS YOUNG, M.D.,
FELLOW AND FOREIGN SECRETARY OF THE ROYAL SOCIETY,
MEMBER OF THE NATIONAL INSTITUTE OF FRANCE;
A MAN ALIKE EMINENT
IN ALMOST EVERY DEPARTMENT OF HUMAN LEARNING.
PATIENT OF UNINTERMITTED LABOR,
ENDOWED WITH THE FACULTY OF INTUITIVE PERCEPTION,
WHO, BRINGING AN EQUAL MASTERY
TO THE MOST ABSTRUSE INVESTIGATIONS
OF LETTERS AND OF SCIENCE,
FIRST ESTABLISHED THE UNDULATORY THEORY OF LIGHT,
AND FIRST PENETRATED THE OBSCURITY
WHICH HAD VEILED FOR AGES
THE HIEROGLYPHICS OF EGYPT.

The subject of this eulogy was one of the most remarkable men in the annals of British science and literature—according to Prof. Tyndall, the greatest man of science that had appeared since Newton; and, as his biography has never been republished in this country, a brief sketch of his life will be fresh and instructive to many.

THOMAS YOUNG was born in 1773, and died in 1829. He was the eldest son of ten children. His parents were both members of the Society of Friends, and strict observers of the principles of their sect, in which their children were carefully educated. Dr. Dalton, the eminent English chemist, was also of Quaker parentage and education; but, while he continued through life to retain his membership of the denomination and to conform to its principles, Dr. Young held the tenets and conformed to the observances of the Society only during his youth. He was a very precocious child. At two years of age he could read with fluency, and had read the Bible twice through before he was four years old. At six years of age he could repeat Goldsmith's "Deserted Village," and had previously begun his Latin grammar. At seven years of age he was sent to a miserable boarding-school, but the next year at the house of a friend he came across a "Dictionary of Arts and Sciences," which he perused with intense interest, and also got instruction in the use of some mathematical and philosophical instruments. When nine years old he was sent to another school, where he remained four years, and made great proficiency in classics, mathematics, and natural philosophy. He also learned the principles of drawing, the art of book-binding, the construction of microscopes, telescopes, and electrical machines, and the use of the lathe. In an autobiographical sketch, he says that, after returning home from this school, he devoted himself almost entirely to the study of Hebrew, and to the practice of turning and telescope-making. He borrowed and studied with great diligence the Chaldee, Syriac, Samaritan, and Persian grammars, and, having got hold of the Lord's Prayer in a hundred different languages, was greatly interested. At fourteen years of age Young became tutor to Mr. Hudson Gurney, who was a year and a half older, and who continued his friend through life, and wrote a biography of him. He wrote a beautiful hand, and, when once requested by a friend of his uncle, Dr. Brocklesby, an eminent London physician, to exhibit a specimen of his handwriting, he wrote a sentence in fourteen different languages. His precocity reminds us of that of J. S. Mill, but it had a far more spontaneous and varied exercise. He went on with his mathematical, botanical, and entomological studies with great ardor, but he was left to entire freedom in their pursuit, and believed that "whoever would arrive at excellence must be self-taught;" and that there was "in reality very little that a person, seriously and industriously disposed to improve, may not obtain from books with more advantage than from the living instructor." Upon this principle, as his biographer remarks, he was self-taught. "He read nothing hastily or cursorily, and his memory was so tenacious that he never forgot what he had once mastered. He wrote exercises and composed in the languages in which he studied. His journals were written in Latin, and his criticisms on French authors in French, and on Italian authors in Italian. His mathematical studies were carried on in a similar manner. He began the six books of Euclid on such a day, and finished them on another; and we hear no more of them. Algebra, trigonometry, and fluxions were dispatched in the same way. He read the 'Principia' deliberately through; and it appears from the remarks in his journals that he had fully comprehended them."

At nineteen years of age, in obedience to the wishes of his uncle, Mr. Young entered upon the study of anatomy and medicine, and from the outset he became an original investigator in this field, his first researches being into the structure of the eye as an optical instrument. At the age of twenty-one, the Duke of Richmond offered him the appointment of his private secretary, at $1,000 a year, and "a place at the duke's table." This he declined on the ground of Quaker scruples, and wrote to his mother that he "was not ashamed to allege his regard for the Society as a principal reason for not accepting the proposal. . . . This event in his life led him, no doubt, to consider how far his position as a Quaker might interfere with his future prospects. He had hitherto adopted their garb and phraseology, but he now began to divest himself of these characteristics, and to mix largely with society. In Edinburgh, where he went at the close of 1794 to prosecute his medical education, he did not scruple to violate the principles of his sect. He spent much time at parties, both grave and gay; went frequently to the theatre in spite of the remonstrances of his friends, took private lessons in dancing and in playing on the flute."

After prosecuting his medical studies in Edinburgh, he made a thorough tour of Scotland at the close of the session of 1795, and returning to England went at once to Göttingen, "where, along with his medical studies, he took lessons in drawing, dancing, riding, and music, in all of which he made rapid progress. He was passionately fond of horsemanship, and there were no feats in that art too daring for him to accomplish."

In 1797 his uncle, Dr. Brocklesby, died, leaving him his house, library, collection of prints and pictures, and fifty thousand dollars in money, which enabled him to pursue his inquiries with greater facility, and in the beginning of 1800 he commenced the practice of medicine in London. In 1801 he was appointed Professor of Natural Philosophy in the Royal Institution of Great Britain, and he conducted its journal along with Humphrey Davy, then Professor of Chemistry. The first year he gave thirty-one lectures, and afterward sixty, which were published in 1807, in two quarto volumes, under the title of "A Course of Lectures on Natural Philosophy and the Mechanical Arts," a work which, notwithstanding its obscurity both in language and in thought, is rich in original and ingenious views, and of inestimable value to the student of physics and the mechanic arts.

It was in May, 1801, when Dr. Young was twenty-eight years of age, that, reflecting on the experiments of Newton, he was led to the discovery of a law which "appeared to him to account for a greater variety of interesting phenomena than any other optical principle that had yet been made known." This was the law of the Interference of Light, which he explained on the principle of the undulatory theory. This theory had been long before propounded by Huyghens and Hooke, but Dr. Young revived it, gave it greater precision of form, and first proved that it accounts for luminous phenomena which can be explained by no other known hypothesis. His views were developed in *Nicholson's Journal* for 1801, in the following propositions:

"I am of opinion," says he, "that light is probably the undulation of an elastic medium, because—

"1. Its velocity in the same medium is always equal.

"2. All refractions are attended with a partial reflection.

"3. There is no reason to expect that such a vibration should diverge equally in all directions, and it is probable that it does diverge in a small degree in every direction.

"4. The dispersion of differently colored rays is no more incompatible with this system than with the common opinion, which only assigns for it the nominal cause of different elective attractions.

"5. Reflection and refraction are equally explicable on both suppositions.

"6. Inflection is as well, and, it may be added, even much better, explained by this theory.

"7. All the phenomena of the colors of thin plates, which are in reality unintelligible on the common hypothesis, admit of a very complete and simple explanation by this supposition. The analogy which is here superficially indicated will probably soon be made public more in detail; and will also be extended to the colors of thick plates, and to the fringes produced by inflection, affording from Newton's own elaborate experiments a most convincing argument in favor of this system."

Regarding medicine as an inductive branch of philosophy, Dr. Young drew up an "Introduction to Medical Literature, including a Practical System of Nosology," which Dr. Peacock, his latest biographer, says, bears much the same relation to the medical sciences that his lectures on natural philosophy bear to the mathematical and physical sciences. It appeared in 1813, and in an Appendix he gave a sketch of animal chemistry, translated from the Swedish of Berzelius by the aid of a grammar and dictionary, without any previous acquaintance with the language.

In the field of philological exploration, Dr. Young exhibited talents of a very high order. He was especially skillful in deciphering manuscripts and inscriptions which had baffled the ingenuity of his predecessors. "The attention of Dr. Young was first devoted to hieroglyphic research by a papyrus in Egyptian characters, submitted to him in the spring of 1814, by Sir W. Rouse Boughton, found in a mummy-case in a catacomb near Thebes. The papyrus was written in cursive Egyptian characters, and Dr. Young's notice of it was appended to a communication, by its discoverer, to the Antiquarian Society. Between May and November of the same year, he analyzed the three inscriptions of the well-known Rosetta Stone, and gave a conjectural translation of the second of the three, which was added to the notice above mentioned." Champollion, the great French antiquarian, was the rival of Young in the work of unraveling the old inscriptions, and a warm controversy grew out of their respective claims which was not free from the tinge of national feeling. Both were men undoubtedly of great originality, and made their discoveries independent of each other. "Dr. Young never failed to do justice to the sagacity, the extensive learning, and the deep research of Champollion; and his own merits were nobly recognized by the countrymen of his rival, when, in 1828, they elected him one of the eight foreign associates of the Institute of France."

About the year 1810 Dr. Young took up the subject of naval architecture, and contributed important improvements to the construction of ships-of-war. In 1816 he was appointed secretary to a commission for ascertaining the length of the second's pendulum, and drew up the three reports which were made in 1819, 1820, and 1821. In 1818 he was appointed superintendent of the *Nautical Almanac.* He had, some years previously to this, gone into the subject of life-assurance, and worked out mathematically the formula of the value of life, and the laws of mortality. He wrote a great number of papers on many subjects in the *Quarterly Review* and in the *Encyclopædia Botanica.* As the undulatory theory of light gradually made its way, being fortified in a remarkable manner by the discoveries of Fresnel, the French physicist, there grew up an increasing recognition of the claims of Dr. Young in regard to the subject. Of his distinguished merits and their ultimate recognition, Dr. Peacock remarks:

"On the 6th of August, 1827, he was elected one of the eight foreign associates of the Academy of Sciences, at Paris, in the place of Volta. The other competitors named were the great astronomers Bessel and Olbers; Robert Brown, the botanist; Sœmmering, the anatomist; Blumenbach, the naturalist; Leopold von Buch, the geologist; Dalton, the chemist; and Plana, the mathematician. This is the greatest honor that can be conferred on a man of science.

"The propriety of the selection which was made by the Institute of France, of Wollaston, Davy, and Young, as the most eminent representatives of English science in that age, was disputed by very few of their contemporaries who were capable of forming a correct opinion.

"The lapse of a quarter of a century, since the grave—within the brief space of six months—closed upon the labors of these three eminent philosophers, has somewhat changed the order in which they were classed by their contemporaries. If Young held the lowest place in the order of precedence then, he unquestionably occupies the highest now. The most brilliant achievements of Davy, whether considered singly or collectively, are probably surpassed in importance by the discovery and demonstration of the interference of light; but while the first received the prompt and unhesitating acknowledgment of the scientific world, and at once secured for their author the honors and rewards which were due to his merits, the second, even after emerging from a long period of misrepresentation and neglect, had to make its way, step by step, as it were, and with various and fluctuating fortunes, against the opposition of adverse and long-established theories, supported by the authority of the two greatest men known to the scientific history of the past and present age."

In the summer of 1827 Dr. Young's health began to decline, and in 1829 he suffered from repeated attacks of asthma, accompanied with great oppression and weakness. He sank gradually, and expired without a struggle, May 10, 1829, aged fifty-six. His disease proved to be an ossification of the aorta, which must have been in progress for many years. Every appearance indicated an advance of age not brought on by the natural course of time, but probably by unwearied and incessant labor of the mind from the earliest days of infancy. We have barely touched upon some of the points of the life of Dr. Young, and, to those who care to pursue it further, we can recommend his admirable biography by Dr. Peacock, published by Murray, of London.

EDITOR'S TABLE.

WHO ARE THE PROPAGATORS OF ATHEISM?

THE hope is indulged by many that, with the progress of intelligence and the increase of liberal feeling, the old conflict between religion and science will either die away, or lose so much of its rancorous spirit that it may be coolly and rationally considered, like any other question. But there are parties who do not seem to think this result desirable, and do all they can to perpetuate the acrimonies that have marked this controversy in the past; and, while we will not say that this bad spirit is all on one side, we will say that the most of it and the worst form of it *are* on one side, and that the side which makes special pretensions to a higher guidance and the loftier virtues. There are religious teachers who habitually make use of science as a scarecrow and bugbear to arouse popular prejudice, and, in doing this, they have not the smallest possible scruple in their representations. We ask attention to the latest illustration of these tactics.

It may be news to some of our readers that there has recently been a vicious attack, on the part of divers religious editors, upon the revised edition of APPLETONS' CYCLOPÆDIA, now going through the press, on the ground that the work is being done in the interests of Romanism. As that charge begins to grow stale, a new cry is raised by the same parties, that the CYCLOPÆDIA is being revised in the interest of atheism. The first attack did not interest us, both because our enthusiasm has never run in the direction of ecclesiastical history, and because we knew the character of the men engaged in the revision to be a perfect guarantee for the intelligent, impartial, and thorough performance of their duty to the public. The revisers of the CYCLOPÆDIA are our nearest neighbors, and their proceedings have interested us from the beginning. What have especially and constantly attracted our attention have been, the vigorous discipline maintained in carrying on the work, and the incessant solicitude and inflexible determination manifested to make it, in the highest degree, truthful and trustworthy. Knowing this so well, we had not the slightest apprehension that a petty onslaught, inspired by sectarian jealousy, could seriously affect the character of the work with the intelligent class to which such a CYCLOPÆDIA must mainly appeal. But in this second attack, which is of wider import, we find ourselves personally implicated, and it therefore becomes proper to notice it; and, when we have shown what it amounts to, the reader will have a pretty good basis for judging the quality of other criticisms emanating from the same source.

In a late number of the *Christian at Work*, a newspaper edited by the Rev. De Witt Talmage, there is a leading article which contains the following passages:

"In the fifth volume of the new and revised edition of APPLETONS' CYCLOPÆDIA, Prof. E. L. Youmans, treating of the Correlation of Forces, says: 'Therefore, it is now regarded as a fundamental truth of physical science, and a fundamental law of Nature, that force, *like matter*, is never created or destroyed.' To affirm that matter is never created, is to affirm that it is eternal. If God and matter are coeternal, then they are identical; and if identical, it follows that God is but an impersonal force acting in and through the inherent properties of matter.

"We are sorry to see APPLETONS' CYCLOPÆDIA giving its sanction to a doctrine so thoroughly unscientific and radically antichristian.

"Last week we were compelled to show that APPLETONS' CYCLOPÆDIA had made some very gracious concession in the field of history to the behests of Romanism. If it is also to lend its aid to the propagation of scientific atheism, the sooner we know it the better.

"The interests of truth are paramount; and that publication is not trustworthy which perverts history in the interest of Romanism, or science in the interest of atheism."

The *Catholic Review*, which was probably aware how much terror there was in the "No popery" alarm, and ought to have learned a little caution, joins the *Christian at Work* in getting up the new scare, and, after making the same quotation from our article, observes: "In other words, Prof. Youmans is allowed, in a work intended for education and general uses, to broach the fundamental heresy that there is no personal God." As an indication of how far Catholics and Protestants are animated by the same spirit, we may note that, when the writers of these articles had been rebuked for their course by other newspapers, they both returned to the subject, and repeated the charges in subsequent issues.

Now, of this formidable indictment we have only to say that it is entirely trumped up, and is without the shadow of a foundation in fact. In preparing an article for the Cyclopædia, on the "Correlation of Forces," we first gave a brief sketch of the investigations that had been made during the past century, and which have brought the whole scientific world to the comparatively new conclusion that, although the different forms of force are convertible, force, or energy itself, is indestructible. After this preliminary statement of the results of experimental investigation, we said, "*Therefore*, it is *now* regarded as a fundamental truth of physical science, and a fundamental law of Nature, that force, like matter, is never created or destroyed." The proposition is stated as an inference, as an induction from observations, as a result of experimental inquiry into the physical processes of Nature, and as a pure principle of science. We were not discussing the subject of matter, but of force, and what we declared in regard to force we assumed in regard to matter that, so far as science knows, it is never either created or destroyed. We did not say that matter is eternal; we did not say that matter never was created, for these are questions beyond the limits of science. We avoided all theological implications, and did not go a hair's-breadth beyond the strict inductive conclusion that in the course of Nature there is no evidence of its creation or destruction. For us there is only one question: Was the statement true? That matter "is never created or destroyed," has been established "as a fundamental truth of physical science and a fundamental law of Nature" for more than a hundred years, or ever since the science of chemistry was founded. Every fact known to chemists or physicists confirms it, and not a solitary fact casts even the slightest doubt upon it. There cannot be shown a particle of evidence within the whole sphere of physical science that a single atom of matter is ever either created or destroyed. The proposition, although for thousands of years it was not believed, is now the corner-stone of all science. If the statement that matter is indestructible be not a truth of physical science, then there are no truths of physical science; if it be not a fundamental law of Nature, then there are no fundamental laws of Nature. The doctrine which we laid down has been held as a demonstration in the whole scientific world, and has become elementary in all our text-books, for generations.

But, for stating it in the American Cyclopædia, that work is charged with being a perverter of science, radically antichristian, and a propagator of atheism. Now, let the reader remember that we are not the parties that have raised this question of atheism. We neither affirmed atheism, nor insinuated it, nor implied it. We strictly avoided a mode of statement which might be twisted into any such construction. It is the theological teachers, the editors of religious newspapers, that thrust the question forward; and they treat it in a way that will entitle them, in our opinion, to rank among the most efficient propagators of atheism. The Rev. Mr. Talmage is an authorized teacher of religion, and, as he is followed by multitudes, it is presumable that his statements have weight with them. He tells them that the AMERICAN CYCLOPÆDIA is a propagator of atheism, because it states in three lines the scientific principle that matter is indestructible. Atheism is here put as the necessary consequence of a demonstrated truth—rather suicidal theology, we should say—but who is the real propagator of atheism, he who simply states the truth, or he who construes it as atheistic? An established principle of science is taken up and subjected to a little theological fumbling, with the result—no God!—let the fumbler take the responsibility. We throw back this charge of propagating atheism where it belongs, upon those who seek every occasion to declare that the question of the existence of God is dependent upon what is going on in the field of scientific research. It was these religious teachers who affirmed that, if the earth is in motion, or was not created in six days, there is no God; and it is these who now say that if evolution, or spontaneous generation, or the doctrine of the correlation of physical and mental forces be true, there is an end to all religion; or, if matter is indestructible, atheism is the consequence—it is these that are sowing the seeds of doubt in the community, and doing more than any other parties to familiarize the general mind with the question of theism in its aspects of assumed uncertainty. We smile at the religious proceedings of the heathen who, after praying to his god for rain until he loses patience, takes him down and thrashes, kicks, and variously maltreats him for neglecting his duties. Yet, after all, how much worse is this than the habit of taking down the *idea* of God, and profanely battering it about like a foot-ball in the logical arena? We have preachers who make the pulpit a kind of conjurer's platform, where the conception of the Deity is manipulated by syllogistic legerdemain, appearing here and vanishing there, now under this hat, and now under that, to the due astonishment of all beholders. Of the pagan referred to, one thing must in justice be said, that, although he pummels his god with great irreverence, he never doubts him. Some of our own theologians, on the contrary, seem to be more possessed with the idea of doubt in regard to the existence of the Deity, than any thing else. They treat it as an open question, and are forever dwelling upon its contingencies, and showing how if this, that, or the other thing be true, then there is no God at all, and every thing like religion is given over to destruction. We are constantly told that there is an alarming spread of disbelief in these days; what else can be expected under such inculcations? Let it be accredited to its chief source—the audacity and folly of those who use science to unsettle faith by forever insisting upon their antagonism; for religion has no enemies so dangerous as those who insist upon staking its truth upon any conditions or results into which it is the legitimate business of Science to inquire.

THE SOCIAL SCIENCE ASSOCIATION.

THE American Social Science Association held its May session in New York, and its proceedings have been made familiar to the public through the newspapers. They were of an interesting character, embracing able papers and discussions on a wide range of topics—education, labor, civil service, finance, sanitary subjects, etc. The earnest consideration of these questions, and the collection and diffusion of information concerning them, is, beyond doubt, a most useful work, and, in doing it, the Association should have the sympathy and God-speed of the community.

But, while recognizing that the aim of this organization is excellent, and much of its work highly commendable, we are of opinion that it falls short of what should be its chief duty. It fails to do that for which, judging by its title, it was specifically instituted. So far from promoting social science, we should rather say that social science is just the subject which it particularly avoids. It might rather be considered as a general reform convention. It is an organization for public action, and most of its members, hot with the impulses of philanthropy, are full of projects of social relief, amelioration, and improvement. Of pure investigation, or the strict and passionless study of society from a scientific point of view, we hear but very little. The President announced its leading object to be the promotion of the civil-service reform, and, if so, of course its leading object is not the determination of the natural laws by which society is constituted and regulated—that is, not scientific. If we remember rightly, at the establishment of the organization, the question, what Social Science is, became a matter of discussion, when the most extraordinary and conflicting views were propounded, and nobody seemed for a moment to suspect that social science is but a branch of general science, having similar objects, and to be pursued by the same methods, as the other sciences. Social science is a knowledge of the phenomena of society, as chemical science is a knowledge of the phenomena of the elemental changes of matter. And as the generalization of chemical facts gives us chemical laws, so the generalization of social facts must give us social laws. Social science is possible just to the degree in which these are arrived at. All the proceedings of the late meeting imply that there are such things as social laws, for, if there are not facts that can be known and compared, and effects that are traceable to causes, and an order of relations which makes it possible to calculate results, then the whole work of such an association is futile. Every project of social amendment which proposes that this thing shall be done rather than that, or that one course of action will result in evil, and another in good, presupposes facts, principles, and a method in the natural constitution of society which it is the legitimate province of science to investigate and determine. And, if this be so, it is obvious that the first and most imperative thing to be done is to trace these principles out, so as to arrive at a system of elementary truths that may be taken as the starting-point and foundation of all active measures of social improvement. The working out of something like a definite and authoritative basis of scientific principles, we say, is the first thing to be done, and this view is sustained by all that we know of the past history of science. All the arts were but blind, and arbitrary, and ineffectual processes, until the sciences upon which they depended were worked out in their fundamental principles as pure questions of research. Not until the laws of physics, chemistry, anatomy, and physiology, were determined by a long course of patient and assiduous observation and experiment, pursued with no reference to any thing but the simple establishment of the truth, did the various arts become settled in their practice, so that they could be pursued with efficiency, economy, and success. Much useful work was undoubtedly done while artisans were still blindly groping without rational guidance, cutting, and trying, and wasting power, time, and materials, in following empirical rules. And so, as we have already recognized, much useful work is done by our social reformers; but, in our opinion, they are attempting to attain ends which, if attainable at all, are not to be reached until there is a far clearer understanding of their conditions, and of the principles by which the progress of society is controlled. The Association seems to be but little in advance of an ordinary political convention. Its teachers appear to start from the fundamental postulate of politics, that human society is the product of government, that its regulative laws are the result of majority votes, and consequently that legislation is to be invoked for every thing. There is little recognition of a sphere of natural activities, spontaneous, and self-adjusting, with which government can only meddle for disturbance and mischief; and, of course, there is no investigation of it. What things it is impossible to effect by political agencies, what had better be left to private enterprise, what is the effect of constant intermeddling, and what are the values and limits of those activities which belong to the natural constitution of society, are not among the primary subjects of inquiry. Yet a true social science must, first of all, throw light upon these questions, and, if its effect is to explode many fallacies—to show that the perpetual motions, the philosophers' stones, and the elixirs of life of social projectors, are only groundless fancies—the result must be accepted with never a doubt that, in place of the discredited crotchets, more rational and valuable devices will arise.

THE PRINCIPLES OF SOCIOLOGY.

The short article on climate and social development which we reprint from advance-sheets of the "Principles of Sociology," by Herbert Spencer, will be welcomed by many as showing the progress of his great work, and that he has at length fairly entered upon that important division of it which deals with the phenomena of society. The "Principles of Sociology," as they will constitute the largest division of his philosophical series, will probably be also its most important division. Mr. Spencer took up social subjects as matters of study in his youth. One of his first publications at the age of twenty-two was, his letters on the "Proper Sphere of Government," in which society was considered from the scientific point of view, or as having its natural laws of regulation and development. Eight years later he published "Social Statics," in which these ideas were expanded and extended, but the completion of this work only brought him fairly to the threshold of the subject. He saw that it must be treated in a far more systematic way, and after ten years of labor directed to a large number of social questions, and working out the principle of Evolution as applied to them, he began his philosophical system in 1860. Fourteen years of labor have brought him to the point from which he started thirty-two years ago, enriched in ideas by a long course of investigation preparatory to dealing with the sociological problems now before him. He begins the "Sociology" as he began the "Biology" and the "Psychology," with the consideration of its data. Those who have examined the "Descriptive Sociology" will remember that at the heads of the tables a class of facts is presented, concerning the various conditions of the country, physical and climatic, with its productions and resources, and the characters of its inhabitants, mental and emotional, by which the state of society is modified, and which of course vary greatly with different communities. After defining Sociology in the first chapter on "Super-Organic Evolution," in which the significance and value of the social instincts exhibited by insects and the lower animals are considered, Mr. Spencer passes in Chapter II. to "The Factors of Social Phenomena," and the subjects just referred to as presented in the tables are now entered upon. Chapter III. is devoted to the "Original External Factors of Social Evolution," and the extracts we now publish are a small part of this exposition. The same questions are touched upon here that Mr. Buckle took up in the early part of his introduction to the "History of Civilization," although it is hardly necessary to say that they are very differently treated.

It may be proper to call attention to one feature of the forthcoming work which will be of general interest. In the preceding volumes on "Biology" and "Psychology," Mr. Spencer has undoubtedly lost some reputation as a popular writer. Those who had read with interest and enthusiasm his brilliant essays, toiled hard over the Biological and Psychological discussions, and got the impression that Mr. Spencer had degenerated in his power of lucid and felicitous exposition. The difficulty, however, was not in the writer, but in the subjects, the facts with which he chiefly dealt being more or less scientific, technical, and foreign to general readers. Dealing with principles and relations, his statements were necessarily abstract, but the trouble was that the terms of the relations and the facts from which the principles were derived were unfamiliar to the common mind. But, in treating of Sociology, or the phenomena of society, Mr. Spencer again enters a sphere of thought the elements of which are no longer foreign to ordinary thought. The "Principles of Sociology" will discuss questions that are quite within the range of popular apprehension, and the difficulty, of which much complaint has formerly been made, will disappear. That Mr. Spencer is very far from having lost or impaired his power of familiar and telling statement we have lately had abundant proof in his series of articles on the "Study of Sociology," a work which is being now widely read and enjoyed by many who were at first under the impression that they would be unable to follow and understand him.

The "Principles of Sociology" will be published in quarterly parts, with regularity if Mr. Spencer's health allows. They will be sold at sixty cents a number, or furnished to regular subscribers at two dollars a year. That the information to be contained in this work will be of the highest value and importance we need scarcely say, and it may be strongly commended on this ground alone; but we appeal to our readers to patronize it, and to induce their friends also to do so, on the further ground that Mr. Spencer is engaged upon a great original and constructive enterprise, and ought to be so amply sustained that he shall suffer no impediment or annoyance of a pecuniary nature in prosecuting his work.

WAR AND EDUCATION.

One of the most striking results of the sudden rise of a military feeling throughout the country, during the civil war, was the influence it exerted upon education. One might have reasoned that if our educational system be, from top to bottom, that perfection of wisdom which many claim for it, it is the one thing that would have remained unaffected by the accidental circumstances of a war into which we drifted. But our system of education is as far as possible from being strongly knit and firmly organized, and as, on the other hand, it is loose and unsettled, it was very naturally affected by the prevalence of the military feeling. This was seen by the adoption of military exercises in a great number of schools, under the idea that they were to become part of the regular and permanent policy of instruction. And where these were not adopted there was still a new impulse in the way of marching, marshaling, and manœuvring the classes and divisions of large schools; and as this was a showy demonstration it was very telling with the public, and was carried in some cases to ridiculous extremes. We once heard a thoughtful teacher remark, after observing a long course of these mechanical exercises, "I begin to think that one thing answers just as well as another for education." The encroachment of the military spirit was also visible in the reaction toward a severer discipline, a more decided advocacy of corporeal punishment, and the substitution of physical for moral forces as motives to conduct. In short, our schools were deeply and in various ways impressed by the new retrogressive spirit which carried away the country. But, as it came suddenly, it proves not to be lasting, and things are now beginning to resume their old course. The most striking indication of the disposition to return to the old order has been recently exhibited in Bowdoin College, at Brunswick, Maine. That institution, it seems, was turned into a kind of half-military establishment, field-drill being a regular exercise. So important was it regarded by Government, that a United States officer was sent there to take charge of this branch of the collegiate work. But the exercises became irksome, and such a bore to the students that, after long and unavailing protests, they at length revolted and almost unanimously refused to drill. The college authorities also refused to yield, and the conflict arrested the operations of the institution. It is a little case of revolution, and as revolution is the mother of war, the war-faculty of the college should not have condemned it too decisively. There seems to be a difference of opinion as to which party was right. The sticklers for discipline and authority of course go with the Faculty, and will no more tolerate the rebellion of the students than they would the mutiny of soldiers against their officers. On the other hand, it is maintained that the republican theory should be carried out in college as well as elsewhere; and that all civil government "derives its just powers from the consent of the governed." Whatever be the result, it cannot be denied that the students have taught the Faculty a wholesome lesson, which is, that they have rights that the authorities are bound to respect, and, if not respected, to be enforced by a resort to extreme measures, too frequently the only way in which rulers can be made to learn any thing.

LITERARY NOTICES.

Tabular Statements, from 1840 to 1870, of the Agricultural Products of the States and Territories of the United States of America. Classified by their Proximity to the Oceans and other Navigable Waters, Natural and Artificial. By Samuel B. Ruggles, Member of the New York Chamber of Commerce. Fifty pages. Price, 50 cents. New York: D. Appleton & Co.

Although this publication takes the form of a pamphlet, and has been made cheap to facilitate its wide circulation, yet we warn our readers not to infer its importance from its form. Carbon is carbon, but an ounce of diamond will outweigh cargoes of coal in value; and so, while knowledge is knowledge, it is possible that a pamphlet may outweigh cart-loads of books in the intrinsic value of what it contains. Until we took up this monograph of Mr. Ruggles on the agricultural resources of the United States, we did not believe it possible to condense in a clear and classified form such a vast array of valuable facts as he has here presented in the compass of fifty pages. To present the resources of a continent, statical and dynamical, the distribution of the elements and the laws of their changes, so as to give us the data for the evolution of a great empire of industry, is an exploit that no man but Samuel B. Ruggles, with his life apprenticeship at the art and mystery of extracting wisdom from statistics, could have performed.

That agriculture is the foundation of

society, and necessarily of all that society contains and accomplishes, is a sufficiently commonplace statement, but it is one of the great facts which must never be overlooked. Agriculture not only furnishes the great mass of materials in the transformation and distribution of which numerous classes of society are occupied, but it furnishes the materials out of which human beings themselves are made. The dust of the earth, and the gases of the air, under the magical enchantment of the forces of the universe, are transformed into the substance of life, and the farmers are the superintending priests of the marvelous and mystical change. This continent is destined to feed and to clothe not only its own increasing millions of human beings, but other and numerous millions of people in distant parts of the earth. One of the first great problems, therefore, which press for solution in regard to the future of this country, is that of transportation for the distribution of products to which commercial exchanges give rise. Mr. Ruggles, hence, takes up the question first of all from the point of view of physical geography, or the construction of the continent, by which all possibilities of movement are primarily determined. His presentation of the resources of the country is not made in mere alphabetical order, as in the official census, but topographically by their proximity to oceans, rivers, lakes, and other facilities of transportation. In accordance with this idea, he cuts up the country into seven great districts, which embrace: I. The New England States; II. The Middle Atlantic States; III. The interior States north of the Ohio, and on the Upper Lakes and Upper Mississippi; IV. The Southern Atlantic States; V. The Southwestern States south of the Ohio and on the Gulf of Mexico; VI. The States on the Pacific and adjacent Territories; and VII. The Territories in and east of the Rocky Mountains.

All the products of agriculture in each of the States and Territories are given in detail, and the rates of increase are also presented by showing the amount of each at the end of the three decades closing with 1850, 1860, and 1870. The whole is then considered with reference to the racial diversities of our population, or by "nationalities." We are thus enabled to compare the different States and Territories, side by side, in reference to the amounts and rates of change of their total population, and the various classes of the population, the amount of land in cultivation, the cash value of farms, and its ratio of increase; the kind of products in each locality, and the profits that arise from them; the yearly product of farms, the agricultural capital per head, and average annual income per head of the Germans, Irish, English, Scotch, Swedes, and natives of the United States.

The agricultural population of the American Union was, in 1870, 5,922,741, and had created and acquired a property in agricultural wealth valued at $11,124,985,747, showing an average value of $1,878 per head, yielding a net yearly income of $360, or nearly $1 per day. Ten States, in 1870, produced more than 21,000,000 tons avoirdupois of cereals, and will probably produce, at the end of the century, 40,000,000 or 50,000,000 of tons annually.

These gross results are sufficiently impressive, but the value of Mr. Ruggles's statement is not in his striking array of aggregates, but in that marvelous analysis by which the discriminations are carried down to the utmost details, so as to bring out the conditions, chances, probabilities, and possibilities of individuals. The Frenchman, or the Dane, who wishes to emigrate to this country, by consulting this pamphlet, may inform himself of the condition of his own class of people, where they go, what they do, and how they have got on in the new country. And so any person in Europe, of special aptitudes and industry, desiring to emigrate, may learn where that particular kind of industry is most practised and most profitable.

But, while this pamphlet is of inestimable value from a practical point of view, and ought to be scattered by millions in Europe, it is no less interesting and important as a contribution of data to political philosophy. The highest form of science is quantitative. We must not only know the fact, but measure it, that is, know it exactly. Until this is done, principles cannot be deduced so as to serve for valuable guidance. Careful statistics are quantitative data for sound social reasoning.

Some say that they are dry, but in all such cases the aridity is subjective. Statistics are the intellectual representations in their most precise form of the phenomena and realities to which they apply. Mr. Ruggles's facts are the foundations of important truths, a report of the circumstances of a great people, a register of their advancement, and the basis of prophecy. His pamphlet is not suitable to be read at a tea-party, and cannot be set to music; but, as Mr. Emerson says that the most important part of education is its *provocative* element, this little digest answers to that character; it is a provocation to endless thought on important questions, and, as such, it may be a valuable help to the education of the American people.

Higher Schools and Universities in Germany. By Matthew Arnold, D. C. L. London: Macmillan & Co. 12mo, 270 pp. Price, $2.00.

Mr. Arnold was, in 1865, charged by the School Inquiry Commission of Great Britain with the work of investigating the system of education for the middle and upper classes of the principal nations on the Continent. In 1868 he published a volume on "Schools and Universities on the Continent," giving the results of his investigation. The present volume is a reproduction in separate form of that part of the original book which related to the German educational system. The Prussian system is taken as an example of what existed throughout Germany. The higher schools of Prussia are gymnasiums and real-schools. There are subordinate branches of each of these, known respectively as progymnasiums and upper burgher schools. They are essentially the same as the former, with the omission of one or more of the higher classes. Gymnasiums lead to the universities, and therefore afford professional training, while real-schools, leading only to business, present a practical course of studies intended to fit the pupil for the ordinary affairs of life. Sometimes the gymnasium has a department corresponding to the real-school, for the advantage of pupils displaying a peculiar fitness for that class of studies. The gymnasium is the stepping-stone to the university. The certificate of having passed the "leaving examination" of the former is an indispensable card of admission into the latter. The gymnasium and real-school have each six classes. Twenty-eight hours for the lower classes, and thirty for the higher, is the required time, per week, for school-work in the gymnasium. This is distributed among the different studies in varying proportions: Latin gets the most—ten hours—natural sciences get two hours in the highest class, and one in the next; religion gets two hours in the four higher classes, and three hours in the two lower ones. The scholastic term constitutes nine years—one year each for the three lower classes, and two each for the higher. The universities have four faculties each—theology, law, medicine, and philosophy. Philosophy embraces the humanities, or languages and their literatures, the mathematical and the natural sciences. Some universities have a distiuct faculty for political economy, others embrace it under the general head of philosophy. All schools, both public and private, are under the control of the state. No one wanting the proper qualifications for a teacher is allowed to set up a private school. Private schools of the higher kind are also discouraged, by the fact that a pupil cannot enter a university without having passed the "leaving examination" of the gymnasium. As is well known, school attendance or efficient private instruction is compulsory on the children of all classes. Catholic schools are maintained for Catholic children, and Protestant for Protestants. A small number of either sect attending a school of the opposite persuasion are not compelled to receive the established religious instruction, but may be provided with instruction of their own sect, at the expense of their parents. In schools where the number of Protestants and Catholics is very nearly equal, an instructor for each sect is appointed. For the government of the schools, the state is divided into eight provinces, and subdivided into twenty-six districts. Each province has a school-board composed of a president and a director, with two or three other members, who are usually a Protestant, a Catholic, and a person practically versed in school matters. Each district has also a school-board constructed on the same principles as the provincial board. The latter govern the higher schools of first grade, and the former those of the second grade, and the primary schools. All of these boards are under the control of an educational minister located at Berlin, with whom they are in continual communication, and to whom they make a general report on school affairs once in every two or three years. There are also seven examination commissions whose business it is to examine applicants for the positions of teachers. The Minister of Education appoints the professors of a university, from names suggested to him by the academical senate. The full professors elect a rector, or, in cases where the king is titular rector, a pro-rector, to serve for one year, and an academical senate, also for one year. The senate consists of the actual rector, the retiring rector, and a full professor of each faculty. Besides the full professors, is a class of assistant professors, and another class called *privatdocent*, which stands partly in the capacity of private tutor and partly as an *attaché* of the university.

Krüsi's Drawing. By Hermann Krüsi, A. M. New York: D. Appleton & Co.

The art of Drawing and the art of thinking are based alike upon two simple principles. The crude leaf-picture of the novice and the accurate landscape of the experienced draughtsman are the results of one and the same process—the combination of *straight* and *curved* lines. The only difference between them lies in the degree of skill with which the lines are combined. The infant, recognizing its mother, displays the same mental process that Newton employed to produce his "Principia." The child recognizes its mother by perceiving her *unlikeness*, to the other persons around her. Newton discovered the law of gravitation by detecting the *likeness* displayed in the movements of falling bodies. The art of thinking, in its rudest as well as its most perfect state, is simply the *detection of likenesses and unlikenesses* displayed in things. The only rational method, therefore, of cultivating the art of thinking—in other words, of education—is to teach the mind to seek for and trace out those likenesses and unlikenesses. To cultivate the art of Drawing, the pupil is taught to distinguish between straight and curved lines, between the effect produced by drawing a straight line in one direction, and that produced by drawing it in another; and further, to distinguish between the effects of combining both kinds of lines in various ways. To draw a leaf, a flower, or a house, he must first recognize the differences in the various major parts and minor parts, and then the difference in the character and direction of the lines required to represent those parts. But that is learning to discriminate between different things and different parts of the same thing, is learning to recognize likenesses and unlikenesses—is learning to think. The child who maps off in his mind the various like and unlike parts of a leaf or a flower with a view to reproducing them on the paper before him, is learning to think in botany, and soon begins to classify leaves, flowers, plants, and trees, according to their peculiarities of form and structure. He that observes the differences and similarities in the various parts of an insect or an animal, for the purpose of making a drawing of that insect or animal, is learning his first lessons in zoology. And he that is able to represent the different forms and structures of rocks and minerals has learned his first lessons in geology and mineralogy. In short, there is scarcely a science that cannot be taught, well taught, and agreeably taught, by the aid of Drawing. For, in teaching a pupil to draw, you cultivate his observation, quicken his perception, and strengthen his judgment. He forms a habit of scrutinizing objects with a view to discerning their component parts, which is an act of observation; of separating the like and unlike parts from each other, and these again into their respective smaller parts, which is an act of perception; and, in comparing the features of the parts with each other for the purpose of ascertaining their likeness or unlikeness, he performs an act of judgment. Thus drawing awakens and develops the three most important faculties of the mind; upon them rests the whole fabric of Thought. By observation of things, we perceive their differences from some things and likeness to others, and we judge or classify them accordingly; and from observation of things we step naturally and certainly to the observation, perception, and classification, of principles which constitute the highest exercise of thought. Drawing, therefore, should be cultivated primarily as a means of developing the mind; secondarily, as an accomplishment or a profession. Instruction in it should begin in early childhood, and continue until education is accomplished; and, instead of being given to a few, it should be given to all.

The work before us appears preëminently adapted to produce natural and rational mental development. The pupil has his attention directed first to straight lines, and, being shown the difference between horizontal, perpendicular, and oblique, he is required to invent forms that can be represented by the combination of two lines. In order to give direction to his efforts, he is furnished with a book containing representations of a few such combinations, but he is not allowed to confine himself to the imitation of these; he is taught to observe in things around him suggestions for other forms. In like manner he is taught to combine three, four, and as many as eight lines. Next, he is led through the same process in the combination of two or more right, acute, and obtuse angles, squares, oblongs, rhombs, etc. Being thoroughly versed in rectilinear forms, he is introduced to curved lines, circles, etc., and taught to combine them in the same manner that he followed with straight lines. As the pupil is herein taught to construct forms from simple lines, it is called the Synthetic Series. And, in order to give the development of his mind a scientific turn, the examples given in the various combinations lead with straight lines to the construction of crystalline forms, and with curved lines to the simpler vegetable and animal forms.

The Analytic Series, which is the next above, begins like the other, with straight lines, the difference being that, instead of constructing forms as in that case, the pupil is here required to pull them to pieces. He is first shown how to bisect and trisect a single line, and then to treat similarly the various sections thus formed. He is next given a square, and required to form designs on the bisection of it; next, on the trisection, and so on, until he becomes perfectly familiar with the innumerable forms that can be produced on the basis of a square, an octagon, or a hexagon. And he is led to observe on which of these bases the objects around him can be represented. He is instructed in the same manner with regard to the circles and ellipses. Thus, by an easy and interesting process, the pupil is brought to perceive and understand what is indispensable alike to drawing and to scientific thinking, the relation of parts to the whole. The examples in this series lead to landscape-gardening, architecture, and descriptive anatomy.

A Perspective and Geometric Series, based on the same plan as the two published series, will follow, to complete the system.

The Doctrine of Evolution: Its Data, its Principles, its Speculations, and its Theistic Bearings. By Alexander Winchell, LL. D. 148 pages. Price, $1. Harper & Bros.

Within the compass of this little volume, Chancellor Winchell has summed up with great fairness, although, of course, with brevity, the leading arguments that are offered both for and against the theory of evolution. He has certainly not failed to do justice to its objectors; and his book is especially valuable as presenting very fully certain arguments against Darwinism that are not readily accessible. As to his own position upon the subject he says: "Should the reader demand categorically whether the author holds to the doctrine of evolution or not, he replies that this seems clearly the law of universal intelligence under which complex results are brought into existence. The existence and universality of a law operating upon materials so various, and under circumstances so diverse, but always evolving a succession of terms having the same values relatively to each other, is a fact which, to the ear of reason, proclaims intelligence more loudly than any possible array of isolated phenomena. But the diversity of the materials with which the law has to deal, brings out a variety of special values for the general terms of the evolutionary series. Mechanical force acts with uniformity, symmetry, and always in one direction, producing results congeric with itself; hence, in the world of mechanical force, the series are complete, calculable, and demonstrative. But, obviously, other modes of activity are possible and probable to intelligent will. When acting in the organic instead of the mechanical world, though conforming still to a fundamental law of evolution, its results may *not* present series which shall be complete, calculable, and demonstrative, but incomplete, contingent, and suggestive. Such seems to be the character of the succession of animals and plants. The series, as an evolution, lacks its first terms; it presents regressions; it yields to the demands of physical correlations and ideal concepts; it betrays everywhere the activity of a force whose law is *not* that which dominates in the mechanical world.

"Mr. Spencer, in stating, in substance, that the efficient cause of evolution is a mode of the Unknowable, expresses our idea exactly in relegating this effect to a Power without the sphere of sensible things. But we differ from Mr. Spencer, *toto cœlo*, in respect to his dogma of the Unknowable, holding that the *causa causarum* is revealed qualitatively to every rational being. The cause of evolution is therefore a mode or volition of the incomprehensible Mind."

Dr. Winchell's book will well repay perusal to those who are interested in the literature of the subject; and the addition of Barrande's argument against Darwinism, in the Appendix, will augment its value to scientific students.

Field Ornithology: Comprising a Manual of Instruction for procuring, preparing, and preserving Birds, and a Check List of North American Birds. By Dr. Elliot Coues. Salem Naturalist Agency, 1874. Price $2.50.

The present work is a supplement to Dr. Coues's admirable treatise entitled "Key to North American Birds," published in 1872, and contains matter originally intended for that volume, but which, owing to lack of space, was left for future publication. The first half of the book consists of eight chapters, in which the reader is told in an easy, entertaining way how to proceed in the collection, preparation, and preservation of birds. As you must "first catch your hare," the author very appropriately devotes the opening chapter to the subject of implements of capture, and, the gun being the chief of these, minute directions for guidance in its selection, care, and use, are given. A short chapter on the employment of the dog as an aid in collecting comes next; and is followed in Chapter III. with directions for general field-work, such as the time of year to make collections, the manner of approaching birds, their recovery after being wounded or killed, and how to dispose them for carriage homeward. The last section of this chapter, on "The Hygiene of Collectorship," contains a good many valuable suggestions that apply with equal force outside the business of bird-collecting. The fourth chapter deals with the subject of notes and labeling; the fifth is on instruments, materials, and fixtures, for preparing bird-skins; the sixth contains directions for skinning, and the preparation of skins; and the seventh treats of miscellaneous matters, such as the determination of sex and age, the study of osteological characters, and the collection and preservation of eggs and nests. The last chapter is on the care of a collection, and gives directions for the construction of cabinets, and the exclusion of insect pests. Drawn from the writer's own experience, which has been most varied and extensive, these instructions cannot fail to be of great use to those proposing the study of birds at first hand.

The second part of the book consists of a check-list of North American birds, intended to replace the one now in use, which, owing to the rapid advance of the science of ornithology, has become defective in many ways. A notable feature of the new list is the reduction of the number of genera, and especially of the number of species given in the old one, in accordance with the growing conviction that naturalists long ago got ahead of Nature in the formation of specific distinctions.

Proceedings of the Georgia Teachers' Association.

It is an encouraging sign to the friends of progress that school-teachers are awakening to the necessity of scientific education. At the seventh annual meeting of the Association, whose report we have before us, held at Atlanta, Georgia, April, 1873, Mr. W. Leconte Stevens, of the Boys' High School of Savannah, delivered an address on "Scientific School Studies," which has in it the ring of the true metal. Scientific education is justly prized, not only for the practical knowledge that it imparts, but also for the discipline it affords to the mind in drawing out and strengthening the perceptive faculties, and inducing clear and accurate habits of thought.

The Great Ice Age and its Relation to the Antiquity of Man. By James Geikie, F. R. S. E., etc. New York: D. Appleton & Co. 8vo., 525 pp. Price $2.50.

There are many persons who would listen with an air of scornful incredulity to the statement that the hills and valleys of New York and New England, which summer now clothes with a mantle of luxuriant verdure, were once a dreary, desolate waste, covered up by a crust of ice many hundred feet thick. Nevertheless, the fact is indisputable; the mountains, the rocks, the configuration of the soil, even the fragmentary stones that lie upon the surface, point silently, eloquently, and immovably, to the fact. Geologists had long noticed, in valleys adjoining mountainous districts, certain long, low ridges, called "sow-backs," running parallel to each other and trending down the valley. They had dug into these ridges and picked out flat, oblong stones, with strange scratches upon their surfaces. They had noticed that, while the mountain-sides looked jagged and rugged from below, from above they presented a rounded and undulating outline to the very base of the mountain. It was also noticed that the rocks on the mountain-sides displayed on their undulating or upper surface the same mysterious scratches or striæ that were observed on the stones embedded in the ridges below. All of these signs greatly puzzled the geologists, and various theories were invented to account for them, but their true significance was not dreamed of until the late Prof. Agassiz, from the study of Alpine geology, announced that they were the results of one and the same cause—glacial action; that is, that the whole face of the country was covered to the depth of two or three thousand feet with solid ice, which, in gradually creeping toward the ocean to shed its bergs, had worn the mountain-sides into waves; broken, scratched, and transported the rock to distant points, and furrowed up the soil of the valleys through which it continued to crawl seaward. Unmistakable evidence existed that this arctic condition of climate prevailed all over Europe, Asia, and America, northward of 45° north latitude; that is to say, that the vast area comprehended within that circle was once covered with ice as completely as parts of Greenland and the rest of the country immediately around the north-pole is now covered. Of course no life could exist under such conditions, and it was therefore supposed that the advent of man, within that circle at least, must have occurred subsequent to their passing away. It is on this point that Mr. Geikie's book throws a flood of light. He describes the evidences of the glacial condition with admirable skill and clearness, and then proceeds to consider its bearing on the antiquity of man. The earth and stones, or "rubbish," that covers the rocky foundation of the countries comprehended in the circle described, is called the "Drift or Glacial Formation," to indicate that it was deposited thereon by glacial action. The drift is divided into two parts, the upper drift and the lower drift. The lower is, of course, the oldest formation. It is composed of a "tough, stony clay," colored like the rocks about which it lies, and small, fragmentary stones, flattened and scratched. The mass of clay and stones is called "till." The till is not laminated, but pressed down in a confused mass, and its coloring shows it to have been produced by comminution of the rock upon which it lies, while the rock itself corroborates that testimony by being scratched and polished like the stones in the till. Thus the till was formed by the grinding of the ice against the rock. Deeply embedded within the till, occur at intervals deposits of sand and gravel, such as we find at the bottom of lakes and rivers. But how could there be lakes and rivers to deposit sediment, while the whole country was covered by a crust of ice more than a thousand feet thick? This is a question that has long puzzled geologists. But only because the true significance of these sand and gravel deposits was not before seen. Mr. Geikie has pointed out that the deposits occurred during an intermission of the Great Ice Age, when the ice melted and disappeared from the land, which became clothed, instead, with trees and plants, and peopled with animal forms. In the course of ages the arctic conditions returned and covered the land again with ice. He has also pointed out that this alternation of temperate and arctic climate has certainly occurred more than once, probably several times. Mr. Geikie's inference becomes still stronger when viewed in the light of Mr. Croll's new theory of a periodic change of climate resulting from the precession of the equinoxes and the increase of eccentricity in the earth's orbit. We have no room for an explanation of Mr. Croll's theory, but must content ourselves with referring the reader to Mr. Geikie's book, where he will find it lucidly stated.

Now, these facts have a very important bearing on the history of man. The remains that we have gathered of primitive man are divided into *paleolithic*, or those belonging to the Old Stone Period, and *neolithic*, or these belonging to the New Stone Period. The *paleolithic* remains are characterized by the rudest kind of stone implements, implements merely chipped out of stone, without any attempt at finish, and from first to last there is no evidence of improvement in their make. The *neolithic* implements, on the other hand, are much better made at the starting-point, and they gradually improve, until they give place to implements of bronze. Again, the *paleolithic* remains are accompanied with the remains of mammalia, such as the mammoth, etc., which are now wholly or locally extinct, while the mammalian remains found with those of *neolithic* man are of existing species. Lastly, the *paleolithic* remains are found in the deposits of sand and gravel we have described as imbedded within the till, while the *neolithic* remains are found only in the upper drift. Thus in one and the same way the existence of man is shown to extend to inter-glacial, probably to preglacial times, and the meaning of the apparent gap in his history between the *paleolithic* and *neolithic* ages is explained. The *paleolithic*, or interglacial, perhaps preglacial man, was driven from the country, or destroyed by the change from a mild to an arctic climate; and, when the arctic conditions passed away for the last time, his place was filled by the *neolithic*, or post-glacial man, from more southern latitudes. We have indicated in a necessarily general manner the central idea of Mr. Geikie's book; it contains a great deal of very interesting information of a subordinate character, which will amply repay perusal.

My Visit to the Sun; or, Critical Essays on Physics, Metaphysics, and Ethics. By Lawrence S. Benson, author of "Benson's Geometry." New York: James S. Burnton. 8vo, 157 pp. Price, $1.50.

If we were called upon to state the object for which this book was written, we should say that it was to display what the author evidently fancies to be a very wide and accurate knowledge of science. With all the flourish and clatter of a Don Quixote charging the windmill, he impinges the mighty lance of querulousness against the feeble form of gravitation, utterly annihilating that venerable body. The atomic theory in chemistry, and the Fayian and Franklinian theories in electricity share the same fate, as do many kindred absurdities long fostered by the ignorance of man. And, as if those blows did not inflict punishment enough on the physicists, they are utterly crushed by the entirely new and astonishing revelation that final causes are unknowable. The present volume is on physics, and the most appalling fact that it contains is the announcement that it is to be followed by similar volumes on metaphysics, ethics, etc.

The Principles of Science: A Treatise on Logic and Scientific Method. By Prof. Jevons. Macmillan. Price, $5.00.

We recently noticed this important and valuable work, and we now again refer to it simply to inform such of our readers as may be interested, that the publishers have issued a special American edition (in one volume) at a reduced price, which will make it more accessible to that large class of students to whom it makes a serious difference whether the price of a book is nine dollars or five dollars.

MISCELLANY.

Volcanic Eruption in the Sandwich Islands.—A correspondent of the *American Journal of Science* writes that, until the past year, the great summit crater of Mauna Loa (Sandwich Islands) has for a number of years shown but few and feeble symptoms of activity. For a few days in August, 1872, there was a brilliant light in the crater, and again on the 6th and 7th of January, 1873, there were vivid demonstrations, which roused the attention of many witnesses. But it was not until the 20th of April, 1873, that a continuous exhibition of mountain pyrotechnics commenced. From that day down to the date of the letter (January 6, 1874), the action within the great caldron was incessant. Most of the time the boiling was vehement. "The scene was never more brilliant than a few nights ago. Sustained jets of molten rock were constantly rising 50 to 200 feet within the mural caldron, and the surgings, puffings, and roarings, have been heard low down the sides of the mountain, and, as some testify, as far as Reed's Ranch, probably fifteen miles." The most distinguishing feature of this eruption, however, was its duration. The eruption of 1855–'56 flowed fifteen months; but this rent the mountain laterally, and flowed longitudinally; whereas the present eruption has made no lateral vent, and found no outlet, so far as known. During all this time Kilauea was unequally active. The great depression of Kilauea, caused by the eruption of 1868, is fast filling up by repeated overflows from the south lake, while all around that lake a vast mound is rising, whose summit is nearly as high as the southern rim of Kilauea, and it may soon overlook it.

Need of a New Chronology.—From the presence of the Egyptian Pyramids, Bayard Taylor thus writes to the *New York Tribune:* "As I rested in the shade, looking up to the gray pinnacles, so foreshortened by nearness that much of their actual height was lost, yet still indescribably huge, I could think of but one thing: we must have a new Chronology of Man. There, before me, the Usher-Mosaic reckoning was not only antedated, but a previous growth, of long, uncertain duration, was made evident. There, in stones scattered about the Desert, were inscriptions cut long before any tradition of Hebrew, Sanscrit, Phœnician, or Greek—clear, intelligible words, almost as legible to modern scholarship as those of living languages. This one long, unbroken stream of light into the remote Past lights up darker historic apparitions on all sides, and sweeps us, with or without our will, to a new and wonderful backward starting-point. Of course, the learned in all countries are familiar with all our recently-acquired knowledge on this point; but is it not time to make it the property of the people everywhere—to discard the unmanly fear that one form of truth can ever harm any other form—to reveal anew, through the grandeur of Man's slow development, the unspeakable grandeur of the Divine Soul by which it is directed?"

Life in an Attenuated Atmosphere.—M. Paul Bert, in a communication to the French Academy, details some further experiments made on himself, with reference to the effect of changes of barometric pressure on life. He entered his large apparatus of decompression, and the pressure was brought down to 450 millimetres (somewhat less than 18 inches of mercury); it was then maintained between this and 408 millimetres (16½ inches) for a little over an hour. These pressures correspond to heights of 13,448 and 16,728 feet. At 450 millimetres the author began to experience "mountain sickness"—a feeling of heaviness and weakness, nausea, fatigue of sight, general indifference, and laziness. Having lifted his right leg, it was thrown into convulsive trembling, which extended to the left, and lasted some minutes. The face was somewhat congested, and the temperature under the tongue increased. He also remarks that he was unable to whistle. The important point of these experiments, however, was this: he had taken with him a small vessel full of oxygen, and, when the pressure had reached 430 millimetres, he inhaled some of it. His pulse, which had risen from 62 to 84, immediately fell to 71, and the mountain-sickness for a time disappeared. Immediately on inhaling the oxygen there was a disagreeable dazzling, and at one time, after three inspirations, he became giddy and fell off his chair, but soon recovered. The author also describes the effects on himself of breathing a super-oxygenated mixture. With a mixture of 45 per cent., he could bear without injury a pressure of only 338 millimetres, which corresponds to the height of Chimborazo; and with 63 per cent. he was able to stand 250 millimetres (less than ten inches), and would have gone farther if his machine had been sufficiently strong. Since M. Bert's experiments, Messrs. Croce-Spinelli and Sivel have made a balloon-ascension to the extraordinary height of about 26,000 feet. They carried up with them a supply of oxygen, and, by using this after the manner indicated by M. Bert, they were enabled to live without inconvenience in an atmosphere of extreme rarity.

Lake Superior Gold-Mines.—Mr. Peter McKellar lately read, at the Toronto Institute, a paper on the gold-mines of Lake Superior. Some Indians from the vicinity of Thunder Bay, in 1871, brought to Mr. McKellar, at Fort William, several specimens of quartz, from an examination of which he was led to think that valuable gold-mines existed in the locality. The paper then described the lodes that had been discovered. The first was the Jackfish Lake lode, which lies about eighty miles west of Thunder Bay. From this lode 126 pounds of ore were sent to the Wyandott Smelting-Works, and yielded at the rate of $500 per ton; of this sum, $40 was derived from silver, and the remainder from gold. The Partridge Lake lode, lying about 100 miles northwest of Thunder Bay, yielded about $30 per ton of ore. In the summer of 1872 another lode, called the Heron Bay lode, was discovered, about 150 miles northeast of Fort William. It was similar to the Jackfish Lake lode, excepting that its yield of gold and silver was not so great. Mr. McKellar holds that these mines might be worked very economically, and that they would yield as large profit as, if not larger than, any others in the world. In the lodes already discovered, the gold was found very evenly distributed through the ore, which is said to exist in large quantities. Iron, lead, and other metals, occur in the neighborhood. The difficulties in developing these mines have been very great, owing principally to the unsettled state of the country. The Indians have refused to help in working the mines until some settlement shall be come to with them, as they fear that white men may come and dispossess them.

Researches on the Zodiacal Light.—Prof. Arthur W. Wright, of Yale College, who for upward of a year has been closely investigating the zodiacal light, has, by means of an apparatus of his own contriving, succeeded in demonstrating that this light is polarized. In the *American Journal of Science*, for May, Prof. Wright describes his polariscope, and the results at which he has arrived in the course of his researches. He finds that the plane of polarization of the zodiacal light passes through the sun. In no instance, when the sky was clear enough to render the bands visible, did their position, as determined by the observations, fail to agree with what would be required by polarization in a plane through the sun; not the slightest trace of bands was ever seen when the instrument was directed to other portions of the sky.

Having thus determined the fact of polarization, the next step was to ascertain what percentage of the light is polarized. For this purpose, the author again had to devise novel apparatus. The amount of polarization was determined to be, "with a high degree of probability, as much as 15 per cent., but can hardly be as much as 20 per cent."

The fact of polarization implies that the light is reflected, either wholly or in part, and is thus derived originally from the sun. The spectrum of the zodiacal light is not perceptibly different from that of sunlight, except in intensity. The author adds: "A particular object in these observations was to determine whether any bright lines or bands were present in the spectrum, or whether there is any connection between the zodiacal light and the polar aurora." The results give a decidedly negative answer to this question. "This is important here," says the author, "as excluding from the possible causes of the light the luminosity of gaseous matter, either spontaneous, or due to electrical discharge. The supposition that the light is reflected from masses of gas, or from globules of precipitated vapor, is not to be entertained, since, as Zöllner has shown, such globules in otherwise empty space must evaporate completely, and a gaseous mass would expand until its density became far too small to exert any visible effect upon the rays of light."

From this it follows that the light must be reflected from matter in the solid state, that is, from innumerable small bodies (meteoroids) revolving about the sun in orbits crowded together toward the ecliptic.

The Great Lava-Flood of the West.—Prof. Joseph Le Conte, of the University of California, visited, during the summer of 1873, the central and eastern portions of Oregon, a vast lava-covered region, and published the results of his observations in the *American Journal of Science* for March and April, 1874. Using the word *lava* as synonymous with eruptive rocks, he says that between 200,000 and 300,000 square miles of surface is one field of lava. It is probably the most extraordinary lava-flood in the world. Commencing in Middle California as separate streams, in Northern California it becomes a flood flowing over and completely mantling the smaller inequalities, and flowing around the greater inequalities of surface; while in Northern Oregon and Washington it becomes an absolutely universal flood, beneath which the whole original face of the country, with its hills and dales, mountains and valleys, lies buried several thousand feet. It covers the greater portion of Northern California and Northwestern Nevada, nearly the whole of Oregon, Washington, and Idaho, and runs far into Montana on the east, and British Columbia on the north.

This enormous mass of matter evidently arose through fissures, and flowed until the streams or masses met, forming an almost continuous sheet. The Cascade Range of mountains seems to have been a source of immense overflow.

The area covered by this overflow cannot be less, says Prof. Le Conte, than 100,000 square miles, with an average thickness of about 2,000 feet, but having a thickness in some places of 3,700 feet. The statement, which seems an extraordinary one, is sustained by the extensive observations of Prof. Le Conte. The Columbia River cuts through the Cascade Range in a gorge a hundred miles in length, with perpendicular cliffs. The cascades of the river are at the axis of the range, and the cliffs here are 2,500 to 3,800 feet above the river-surface, and are composed of lava, tier upon tier, from top to bottom. Considering surface erosion, 4,000 feet is regarded as a moderate estimate for the original thickness of the lava-flood at this place.

But the entire thickness of the lava has been cut through, and the surface revealed on which the flood was originally formed. Here, at the river's surface, underlying the mountains of lava, are remains of ancient forests, and evidences of interesting geological changes.

There occurs at the river's edge, and about fifteen feet upward, a layer of coarse conglomerate; on this, a layer which appears to have been a dirt-bed, or old-ground surface. On this surface were found two silicified stumps, with their roots spread out, one of which was two feet in diameter, the roots reaching over an area twenty feet in diameter. Trunks of other trees were seen. Over this was a layer of stratified sandstone, with beautiful impressions of leaves of several kinds of forest-trees. Upon this lies about 100 feet of conglomerate, resembling drift, in the bottom of which were found trunks and branches of oaks and conifers. Upon the conglomerate the lava lies in columnar masses to a height of 3,300 feet.

The geological age of the wood and leaf-bearing stratum is believed to be miocene, or middle tertiary, and, if so, the lava-flood began to occur during or after the miocene.

Why Paints crack and peel.—A writer in *The Hub* thinks that the cause of paint cracking and peeling is to be found in the water which is contained in linseed-oil, as it comes from the hands of the manufacturer. He made the experiment of boiling linseed-oil by the heat of steam, until all the moisture was expelled from it. On using this oil, without any drier, it was found to dry in one-half the usual time. He then mixed with it some siccohast, using only half the usual quantity employed to dry oil not boiled, and obtained similar results. "The introduction," says he, "of steam into the linseed before grinding aids in the expulsion of the oil; but it must stand a long time to precipitate the water completely. Boiling oil by steam does not change its complexion, save that it renders it clearer, and less liable to turn yellow with white pigments."

Results of the Polaris Voyage.—The following is from Dr. Bessel's memoranda of the discoveries of the expedition:

1. The Polaris reached 82° 16′ north, a higher latitude than has been attained by any other ship. Captain Buddington's testimony is very definite as to the impracticability of pushing a vessel farther north than the point which they reached.

2. The navigability of Kennedy Channel has been proved beyond a doubt.

3. Upward of 700 miles of coast-line have been discovered and surveyed.

4. The insularity of Greenland has been proved.

5. Numerous observations have been made relating to astronomy, magnetism, force of gravity, ocean physics, meteorology, zoology, ethnology, botany, and geology, the records of which were kept in accordance with the instructions supplied by the National Academy. A ninety-fathom sounding along the coast of Grinnelll-and brought up a highly-interesting organism of lower type than the *Bathybius* discovered by the English Dredging Expedition. It was named *Protobathybius Robesonii*. The natural-history collections were nearly all lost. They consisted of mammals, nine species of fur-bearing seals; birds, twenty-one species; insects, about fifteen species, viz., one beetle, four butterflies, six diptera, one bumble-bee, and several ichneumon-flies; also two species of spiders, and several mites.

It was found that the land was rising. Garnets of unusual size were found in latitude 80° 30′, having marked mineralogical characteristics by which the identity of some garnets from Fiskenaes was established. From such observations it became evident that the drift, which abounded on the land, runs from south to north.

Australian Compliment to American Microscopes.—But a short time ago, a small number of microscopists met in Melbourne, and decided to form an organization under the name "Microscopical Society of Victoria, New South Wales." The first general meeting of the Society was held in the Royal Society's Hall, October 10, 1873. About forty gentlemen were present, and a good exhibition of instruments and work was made. The president, Mr. W. H. Archer, read an address, from which we extract the following significant passage. Geologically, it is the oldest continent speaking to one the next in age; although politically it is the most recent of the peoples, speaking of science among one but a little older than themselves:

"One of the most interesting and practically useful objects for occasional investigation and discussion at our meetings will be the accurate determination of the real value to working microscopists of the various stands, objectives, and accessory apparatus so prodigally developed by makers in the mother-country. But, indeed, we should not confine ourselves to the results of English industry. Hartnack, of Paris, appears to be leading the way on the Continent to greatly-improved optical work; and Tolles, Spencer, and Wales, are said to be doing marvels in America. I hope to see the day when we shall have choice proofs of what the whole microscopical world can produce collected around us, and carefully tested by our own eyes and hands, in our own hall in Melbourne. One other thing, gentlemen, you as well as I should be rejoiced to see, and that is a really useful microscope of Victorian manufacture. At present, the idea is naturally provocative of a smile, but I cling to the belief that not only among the adult immigrant population, but even among our native-born youth, we shall some day find thorough mechanicians, who will emulate the marvelous skill and persistent energy of their forefathers. Look at the triumphs of the American microscope-makers. Their conquests are literally but of yesterday and of to-day. A generation ago microscopes were a rarity in America. In the year 1840, when the United States Exploring Expedition to the South Seas, under Commander Wilkes, was fitting out, it was thought necessary to have a microscope. The various makers of scientific and philosophic instruments were applied to, but none of them could furnish the expedition with the thing desired. In this dilemma a private individual was appealed to, and an instrument thus finally obtained, in the shape of an inferior French microscope. How, then, did the present flourishing state of affairs come about? Simply by the genius of a self-taught man. He was a backwoodsman, and had pored over an old cyclopædia, and turned the optical knowledge contained therein, as far as in him lay, to sound practical account. At the age of twelve years he made his first lens. One day he happened to be shown a microscope constructed by Chevalier, of Paris, and the thought struck him that he would try to make a similar instrument. He succeeded, and his glasses were able to resolve a test which similar objectives of the first English opticians had hitherto failed to define. His name was Charles Spencer. And now his pupil Tolles, and Wales, a pupil of Smith and Beck, with Gronow, Zentmayer, and others, form a galaxy of American mathematical instrument talent that appears from recent accounts to be holding its own against the whole of the world. Is there not here a ground for the hope I expressed a little while ago? Surely after this example of Spencer, the young backwoodsman, many here present may live to see the day when a finished microscope shall be presented to their delighted gaze by the hands of an Australian townsman, at least, if not by an Australian bushman."

The Improvement of Human Life.—An extremely valuable paper by Dr. Edward Jarvis, on "Political Economy of Health," published in the Fifth Annual Report of the Massachusetts Board of Health, groups together very strikingly the vital statistics of various countries, to show the effect of the advance of civilization in protracting the term of human life. By better adaptation of means, circumstances, and habits, says Dr. Jarvis, man's life has been expanded, his strength increased, and his days on earth prolonged. By the improvements in agriculture and in vegetable and animal life, he has obtained better and more constant food, and is therefore better nourished. By the improvements in the arts he is better clothed and housed, better protected from the elements. The progress of civilization is best manifested in the progress of vitality. There is less sickness, and that which visits humanity is less destructive than in former ages.

In ancient Rome, in the period 200 to 500 years after the Christian era, the average duration of life in the most favored class was 30 years. In the present century the average longevity of persons of the same class is 50 years. In the sixteenth century the average longevity in Geneva was 21.21 years; between 1814 and 1833 it was 40.68, and as large a proportion now live to 70 as lived to 43 three hundred years ago. In 1693 the British Government borrowed money by selling annuities on lives from infancy upward, on the basis of the average longevity. The treasury received the price and paid the annuities regularly as long as the annuitants lived. The contract was mutually satisfactory and profitable. Ninety-seven years later Mr. Pitt issued another tontine or scale of annuities, on the basis of the same expectation of life as in the previous century. These latter annuitants, however, lived so much longer than their predecessors, that it proved to be a very costly loan for the Government. It was found that while 10,000 of each sex in the first tontine died under the age of 28, only 5,772 males, and 6,416 females in the second tontine died at the same age one hundred years later. The average life of the annuitants of 1693 was 26.5 years, while those of 1790 lived 33 years and 9 months after they were 30 years old.

From these facts, says Dr. Jarvis, it is plain that life, in many forms and manifestations, and probably in all, can be expanded in vigor, intensity, and duration, under favorable influences. For this purpose it is only necessary that the circumstances amid which, and the conditions in which, any form of life is placed, should be brought into harmony with the law appointed for its being. By this means the intelligent world has been and is now continually adding to the vitality of the vegetable and animal kingdom, as far as they are brought under their control. Man has increased his own life also, in so far as he has conformed his self-management to the requirements of the vital law.

Fossil Edentates.—Prof. O. C. Marsh, in the current number of the *American Journal of Science*, describes some new fossil mammals, being edentates of a stupendous size. They go back very much farther, geologically, than any American species previously described. Some of them are from the Upper Eocene of Wyoming Territory.

NOTES.

A considerable trade is now carried on between Australia and San Francisco in kangaroo-skins. At the latter place they are much in vogue, and when tanned are said to produce a thin, supple leather, softer than calf-skin and more impervious to water.

Dr. T. C. Renner writes to the Department of Agriculture, that several years ago he collected some poke-root (*Phytolacca decandra*) for medicinal purposes, and spread it at several places about the house to dry. Soon afterward he observed that there were many cockroaches lying dead, and upon examination found that they had been partaking freely of the poke-root. Some of the root was placed near their haunts, and the result was that it rid the premises of those insects. Since then he has communicated the remedy to others, who have tested it with satisfactory results.

The Italian Government having invited Father Secchi, S. J., to remain at his post, he declined to do so unless the pope's rights over the observatory were recognized. The Government has acceded to his request, and is walling off from the rest of the expropriated Collegio Romano the portion comprising the observatory, in which Father Secchi and his assistants are to remain undisturbed.

The first oil-field around Titusville, Pa., appears to be again becoming productive. Territory long since abandoned and deemed worthless promises to give as abundant a yield of oil as any in the whole oil-region. Several wells recently sunk in the territory yield from 100 to 500 barrels per day.

Benjamin Thompson, afterward Count Rumford, was born in Woburn, Mass., and not, as might be inferred from a paragraph in the April Monthly, in Concord, N. H.

About the year 1300 coal was first discovered in England on the banks of the Tyne, and was introduced as fuel into London about the year 1350. Its use, however, was in 1373 forbidden by proclamation, in consequence of its effluvia being considered injurious to health, by corrupting the atmosphere, and for many years it remained unused. At the close of the century, however, the value of coal became recognized, and its application and consumption extended.

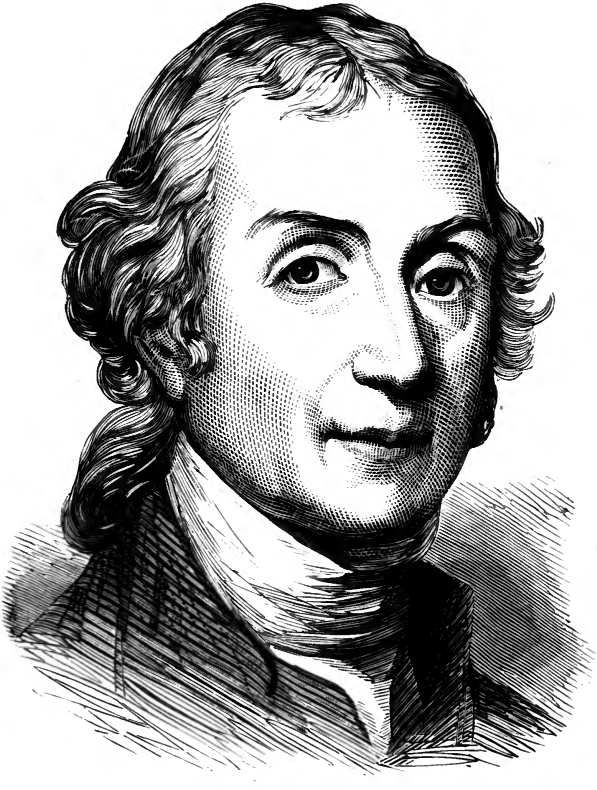
Poggendorff's *Annals of Physics and Chemistry*, a monthly periodical, has now been in existence fifty years, and has been under the sole editorial direction of Prof. Poggendorff for that long period. Some of the friends of the venerable editor have agreed to assume editorial charge of the work for one volume, thus allowing the veteran a four months' vacation. The entire number of papers published in the *Annalen*, during the fifty years of its existence, is 8,850, and among the 2,167 authors who have contributed to its pages are Liebig, Berzelius, Faraday, Brewster, Becquerel, and many others.

The French Assembly have voted a pension of 12,000 francs to M. Pasteur for his eminent services to science, more particularly for his researches into the causes of the diseases of the vine and the silk-worm.

The *American Naturalist* calls for a careful geological and zoological survey of Massachusetts. While surveys are going on or have recently been completed in so many other States, it is not particularly to the credit of Massachusetts that a thorough survey of its geological and biological riches has been neglected It is now over thirty years since the original incomplete survey of the State was made. Since then physical science has changed so much that the work done then needs to be reviewed and greatly extended.

Died, in Charleston, S. C., February 28th, Rev. John Bachman, aged eighty-four years. He was associated with Audubon in the preparation of his great work on ornithology, and was the principal author of the work on the quadrupeds of North America, illustrated by Audubon and his sons. He was also the author of numerous other works and papers on zoological subjects, all evincing superior powers of observation, and marked by excellence of statement.

Peter Andreas Hansen, Director of the Observatory of Seeberg, near Gotha, died on the 28th of March last, aged seventy-nine years. He is chiefly famous for his elaborate investigation of the moon's motion, and the tables constructed on the basis of his theoretical labors. These tables were published in London, in 1857, at the expense of the British Government.



Dr. JOSEPH PRIESTLEY.

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PRIESTLEY'S DISCOVERY OF OXYGEN GAS.[1]

By JOHN WILLIAM DRAPER, M.D., LL.D.

ANIMAL instincts, when properly considered, are often found to be connected with physical laws. Even in the case of man, his gratifications and dislikes frequently originate in the imperceptible action of external circumstances, and those feelings, and the impulses to which they give rise, are, in the scheme of Nature, strangely bound up with other things, with which, at first sight, they seem to have no kind of connection.

Thus, with what pleasure the whole animal world rejoices at the coming of spring! There is a heart-felt delight, not limited to the higher races, but common to all. With the returning temperature, birds, and beasts, and insects, prepare for the duties of a new year, and every thing seems full of animation and life. Even the illiterate man cannot look unmoved on the green tint stealing over the fields. Perhaps his sentiments may in some measure be connected with a perception that there is a promise for the gratification of his baser animal appetites, and that this prosperous beginning will end in the production of corn and wine for his use. But, behind these, which are the more obvious, there are other causes for rejoicing—causes which can only be fully appreciated by the intelligent, and which have been made plain only by the advances of the highest branches of human knowledge.

How often is our admiration aroused by the work of mechanical artists!—the steamship, which day after day has continued its unceasing and successful struggles with the waves, or the chronometer, which, once wound up, keeps on for months together its regulated motion. Yet how far are all these contrivances outdone in the mechanism of every living man! Of his double nervous system, one part, the intellectual, observes its mysterious periodicities, its time of activity and time

[1] A Lecture; see Sketch of Priestley in present number.

of repose, its time of wakefulness and time of sleep; the other never sleeps till death, but keeps up its incessant action; the beating of the heart, the introduction of air by breathing, involving millions of movements which never fatigue us, and of which we are indeed, for the most part, unconscious. And, now, who would suppose that these, the highest and noblest results of a far greater mechanician than man, are ultimately connected with the return of the spring; and that, in fact, the continuance of the life of man is indissolubly linked with the putting forth of the buds of a tree?

Yet so it is; and surely we cannot spend an hour more profitably than in tracing that connection. Such studies are appropriate to all intelligent men. And, when another spring revisits us, we shall not find that this hour has been entirely lost. The reflections it may suggest will, perhaps, increase the pleasure with which we view the return of that great natural phenomenon.

In thus explaining to you the connection subsisting between the animal and vegetable kingdoms, I shall have, in the first place, to introduce an account of the great scientific discovery of the last century—the discovery of oxygen gas—an event rivaling in importance the establishment of the doctrine of universal gravitation by Sir Isaac Newton, in the preceding age.

Until the middle of the last century an opinion universally prevailed that the atmospheric air is a perfectly homogeneous and undecomposable body—that there is but one kind of air, that which we breathe, and though in mines, wells, and other deep and solitary places, substances somewhat analogous occur, they are in reality nothing more than vitiated forms of atmospheric air, which has gathered poisonous qualities from mineral exhalations. From the remotest times these opinions had prevailed. Many of the Greek philosophers looked upon the Olympian Jupiter as only an emblem of the atmosphere, and little suspected that the day would come when that great god of antiquity would be anatomized, dissected, and his various parts and qualities displayed. How often do things which have struck one generation with awe become commonplace affairs in another!

It so happened that, though, from time to time, after the thirteenth century, different gaseous substances were accidentally encountered, they all possessed the quality of extinguishing the light of a candle, and were therefore incompetent to support combustion, and when breathed were destructive of animal life. The doctrine that these were only vitiated forms of the atmosphere seemed very plausible, and this interpretation was received until the middle of the last century, when the capital discovery was made by Dr. Priestley that the air is not a simple substance, and that there is a great family of analogous bodies, each of the members of which possesses peculiar properties. He completely broke down the ancient doctrine of the elementary nature of the atmosphere.

You can scarcely form an estimate of the immense consequences that followed this discovery. It was found not alone to affect chemistry, properly speaking, it threw a flood of light on every allied science. The chemistry of that day was overthrown. Without any exaggeration, I characterize it as the capital discovery of the last age, rivaling in its importance and in its results the great discovery of the preceding century, universal gravitation, by Newton. Extended by the chemists of England, France, and Germany, it has utterly exploded metaphysical physiology, which, taking its origin in the dark ages, has been the great barrier to the progress of rational medicine. Whoever will take pains to study with attention the works devoted to the exposition of that ancient system, must be struck with the impenetrable obscurity in which it is enveloped. You turn over page after page, and the more you read the more you become confused. It is a constant putting of words for things, of phrases for facts. Even in the hands of the most powerful writers, metaphysical physiology is essentially unintelligible; but not so with that other physiology which has arisen in our times, all its statements are clear, precise, distinct; it relies on the exact sciences, such as chemistry and natural philosophy, because it is itself exact. The progress of all the departments of human knowledge is often the same. Two thousand years ago the pagans peopled Olympus with many gods; and so in the infancy of medicine the corporeal frame was peopled with many intangible forms—a soul, a mind, a vital power, an instinct, a nervous agent, an aura, and animal spirits without end. But a better knowledge of these things is fast teaching us the eternal truth that, as there is but one God in the heavens, so there is but one spirit in man; a presiding agent that supervises and directs all; that all the acts of life are brought about by the inhalation of atmospheric air; and that every living animal owes its so-called vital properties to the action of air within its system; that there thus arise oxidations and other alterations in the economy, so that not a movement takes place, nor a thought occurs, without contemporaneous structural changes. The introduction of air by breathing is, I say, the fundamental fact in physiology; nay, more, it is the fundamental event in the action of the brain. I rest my opinions not on scientific facts, though they are numerous and irresistible, but I go at once to an authority far beyond all chemists and metaphysicians. In vain the physiologist asks me to deny the combustive influence of air in the body, and affects a fictitious fear of the tendencies of such a doctrine. Shall I not believe the positive declaration of him who is the artificer of these beautiful contrivances?—shall we accuse the Almighty of materialism when he tells us that "he breathed into his nostrils the breath of life, and man became a living soul?"

The circumstances that first direct the mind of a philosopher to discoveries destined to exert an influence over the whole human race cannot fail to be full of interest. So it is in the present case. It happened that Priestley, who resided near a brewery in the town of Leeds, in England, accidentally observed that the beer during its fermentation in the vats gave forth a remarkable aërial substance. The flame of a lighted stick immersed in it was at once extinguished, and the smoke floating on the top of the stratum showed that it was very heavy, a result which was perfectly confirmed by the observation that, invisible and intangible as it was, this air could be poured from vessel to vessel like water, and in the vats in which it originally occurred it would overflow their edges and descend to the door, along which it would run like a stream, its course being readily tracked by the expedient of putting a lighted stick into it, and observing the extinction of the flame. Moreover, he found that it would dissolve in water, for, if dishes of that liquid were placed where it had access, an agreeably acidulous and sparkling fluid, soda-water, was formed. And that the agent which brought all these results about possessed a physiological potency, was proved by the fatal fact, too often known in such manufactories, that if, by accident it was breathed, death at once took place.

The substance which Priestley thus first encountered was that known to us as carbonic-acid gas; it had already been studied under other circumstances by Black and older chemists. I mention it here because it led Priestley to that long-continued investigation of factitious airs, which was crowned by the great discovery of oxygen gas.

We have seen with what acuteness Priestley detected differences between the gas just mentioned and common air. It is a striking fact, verified over and over again in the history of science, that the most imposing results may be presented to the acutest mind, and their significance and value remain undetected. Priestley, in 1771, having exposed some saltpetre to the fire, disengaged oxygen, experimented with it, and even showed its energetic power of supporting the flame of a candle, and yet the value of these truths entirely escaped him. Three years subsequently he submitted one of the compounds of quicksilver to the force of the sun's rays, converged by a burning-glass, oxygen again escaped, and this time he secured his discovery.

He was not long in recognizing its importance. One after another, as the properties were developed, the value of their consequences was apparent. First, a lighted candle, far from being extinguished, burnt with increased brilliancy, and substances commonly reputed incombustible, such as iron and other metals, were consumed as though they were wood. The doctrine of vitiated airs disappeared at once. Here was a substance possessed of all the chemical energies of the atmosphere, only in an incomparably more intense degree. If there were vitiation at all, the air itself was a vitiated form of this gas. Then, too, he found that it could sustain completely the breathing of animals, and that, in reality, it was absolutely essential to the discharge of that function, a fact which led him to apply to it the epithet "vital air;"

and lastly, that the atmosphere itself, far from being, as the ancients had supposed, a simple homogeneous mass, contained this substance as its active principle, mingled with four times as much of another different body.

Here, before explaining the consequences of this great discovery, and showing the position in which it stands, I may be permitted to spend a moment in relating the melancholy but interesting history of its author. It is a lesson which ought not to be lost. Born the son of a tradesman, who died while he was young, and left him very poor, his early manhood was spent in the useful but tedious duties of a village school-master. His attention being turned to theology, he subsequently became the pastor of a Presbyterian church. We must not impute it to mental weakness, but rather to a pursuit of the truth, that in succession he passed through many phases of religious belief, and four different sects, the Presbyterian, Arminian, Arian, and Unitarian, received him as a votary. This is not the occasion nor the place to explain the causes that led him in this course. It is only for us to judge of so great a man with charity. But, imbued as he was with a deep religious sentiment, and feeling that even the most exalted objects of this life are not to be compared with the importance of another world, he regarded his philosophical pursuits as a very secondary affair, and gave much of his time and talent to controversial theology. He seems to have come to the conclusion that it was incumbent on him to make a religious war. As his biographer says, "Atheists, Deists, Jews, Arians, Quakers, Methodists, Calvinists, Catholics, Episcopalians, had alike to combat him." In more than a hundred volumes which he printed, each of these found an adversary of such force and vigor (and it was impossible with such a man that it could be otherwise), that their ablest theological writers were overmatched. By the established Church of England he came to be regarded with such feelings, that instances occurred in which those who had successfully answered him were rewarded with the highest dignities; a circumstance which gave origin to his remark that he appointed the Bishops of England.

But this was not all. The first French Revolution broke out, and, his ardent mind imbibing with enthusiasm the seductive doctrines of the times, he added to his religious disputes those of a political partisan. As the different sects had in succession stood in fear of him, so now the government took alarm; it knew his philosophical reputation and ability. The story is a sad and short one. A mob assembled round his dwelling, which they committed to the flames; the houses of those who were known to be his friends shared the same fate; he narrowly escaped with his life; and for three days one of the chief cities of the nation was the scene of riot. All his philosophical instruments, most of them constructed by himself, his manuscripts, his library, the fruits of a frugal life, were destroyed; and, eventually driven from his native country, in his old age he found an asylum in the United States, where Mr. Jefferson, then President, received him with kindness and distinction, and in America he died.

In relating this melancholy but instructive story, we cannot but remark how Priestley forgot that the experience of all nations and of thousands of years has proved the utter impossibility of any one man convincing the whole human race, and converting them all to his views. He shut his eyes to that anarchy of opinion infesting the world, brought on in no small degree by such polemics as those in which he delighted. In an exact science, like chemistry, he could describe some new discovery, and every man in Europe at once admitted its truth. He never realized how different it is in politics and theology. The library of volumes he wrote on these topics has already dropped into that gulf of oblivion which has received all the works of the authors of the early and middle ages, and no man cares to learn what he wrote or what he thought of the matter. But not so with his philosophical labors; they stand out clear and distinct, monuments of the advance of the human mind in knowledge and power during the eighteenth century. His discovery of oxygen gas will last as long as the world endures.

From the life of this remarkable man we may draw a lesson, a lesson which the highest authority, with brief emphasis, has given us—"Study to be quiet, and mind your own business." We here see a great man effecting his own shipwreck on the shoals of politics and controversial theology. To what an eminence might Priestley have attained, if he had limited himself to those objects for which Providence had so well fitted him, and abandoned the vain pursuits in which he delighted, to men of less intellect and force! How is it possible, in our times, for a man to be at once a great philosopher, physician, theologian, politician? He must make his selection of one pursuit and stand by it. Not that I would wish an intelligent man, whose opinions must always control or guide those of a large circle around him, to shut himself up from public affairs of great interest. If he perceives, in those to whom the authority of government is committed, a disposition to jeopardize national interests, and pursue an obvious career of profligacy, let him resist them with whatever influence he has, and give his support to those who are the upholders of the peace, prosperity, and happiness of the nation. I would have him set his face against all social disorganizers, and give no countenance to religious disputants.

In thus freely criticising, for your benefit, a character historic in science, I trust I have not infringed in an unkind spirit on the generous maxim, "Say nothing but good of the dead." I join in the dying exclamation of Crœsus, the King of Lydia: "Judge not of the life of a man until you have witnessed his death." And what can there be more touching, or even more beautiful, than the last scene of

Priestley's life? It dissipates the remembrance of all his disputations and all his errors, and shows us that beneath these there was a deeply pervading and redeeming faith. When his little grandchildren were brought to his bedside to bid him good-night, he uttered his last words: "I go to sleep like you, but we shall wake together, and I hope to eternal happiness."

To return from his life to his discoveries. Priestley soon found that oxygen—I give it the name under which it has subsequently passed—was absolutely essential, in all cases then known, to the support of flame and fire, and that animal life depended on it; that a man, by breathing in a limited space, would soon exhaust it of so much of this gas that suffocation would ensue; that the atmosphere, in reality, is a reservoir of it, from which every thing possessing the attributes of an animal abstracts it. It has been shown by succeeding chemists, to such an extent does this abstraction go, that a single man will each year consume about 800 pounds' weight. Considering, therefore, the enormous amount of animal life, the same respiratory process being common to the minutest insect and the largest quadruped, there must be a constant tendency to alter the constitution of the air, for, in proportion as we take from it oxygen at each inspiration, we restore at each expiration an almost equivalent bulk of carbonic acid—a double change, the removal of a vital element, and the addition of a poisonous gas.

But Priestley also showed that, in artificial atmospheres, such as he made, animal life could not possibly be maintained if there were any great reduction of oxygen, or any great increase of carbonic acid. More recent experiments prove that the most striking physical and moral effects arise when men and animals are made to respire atmospheres of a different constitution—effects such as we witness in the case of chloroform and sulphuric ether—a remarkable discovery, not, as is commonly supposed, of only a year or two back, but made by Berzelius, who, twenty-four years ago, gave the most extraordinary, and in a scientific point of view the most important, instance of the kind yet produced—the instantaneous and deep sleep brought on by the respiration of hydrogen; a fact which, in the recent discussions about the priority of that discovery, has been strangely forgotten. From the effect thus arising when the constitution of the medium we breathe is in any degree disturbed, it necessarily follows that, ever since animal life appeared on this earth, the composition of the air must have been nearly unchanged. But here arises a great and obvious difficulty. If the life of men and animals can only be conducted in such a medium as our atmosphere, and if such extensive changes as I have described are constantly impressed on the air by those beings, how does it come to pass that, after the lapse of a few years, it does not gather a poisonous quality? There must be some agency at work, continually tending to prevent that result. The consideration of what that agency is introduces us to the second branch of Priestley's discovery.

He had put some mice in a glass containing atmospheric air, closely stopped, and found, as usual, that they died of suffocation as soon as the air became sufficiently impure by their breathing; an absolutely poisonous quality being gradually assumed. But, if a few vegetable leaves, or a small plant, were placed in the glass, and exposed to the sun, in a very short time the poisonous quality disappeared, and the power of supporting animal life was regained. Here, then, was an unexpected result—a discovery that gave a solution to all the difficulty, and which has been verified in its minutest details by more modern experiments. It has revealed the great and interesting fact that plants and animals stand in a relation of antagonism to one another; that whatever changes the one tends to impress on the air, the other undoes; and that, while animals discharge their duty in consequence of their being living and moving things, plants perform theirs under the influence of the light of the sun; for these changes do not go on in the dark.

Let us look at these facts by the aid of modern chemistry, premising that oxygen is an invisible substance, existing in the air, and that carbonic acid arises from its union with carbon. When carbon burns, it is merely uniting with atmospheric oxygen, and the resulting carbonic acid escapes away under an invisible form. So, too, when a man breathes, he draws in oxygen from the air; it is distributed to all parts of his system, and, combining therein with carbon, turns into carbonic acid, which is expelled when he throws out his breath. Every animal, therefore, to use the language of chemistry, is an oxidizing machine, the physical end of its existence being to rob the air of oxygen, and put back, in its stead, carbonic-acid gas.

With plants it is just the reverse. As long as the sun is shining upon them, they take carbonic acid from the air, and, decomposing it by their leaves, they set free its oxygen, which escapes away; its carbon they appropriate. With it they form their various parts, their stems, roots, flowers, seeds; but they do this only so long as the sun shines, and when night or winter comes the process stops.

The animal, therefore, takes from the air oxygen, and turns it into carbonic acid; the plant takes that carbonic acid, and turns it back into oxygen, which has thus discharged the great office of carrying carbon from the bodies of animals, and transferring it to the systems of plants. In what an interesting relation do the two kingdoms, the animal and the vegetable, thus stand to one another, not alone as respects the air in maintaining its constitution uniform by a mutual antagonization, but also as respects their own structures! The elements of which plants are formed have all been derived from the preexisting parts of animals; and the elements of which animals consist, from the preëxisting parts of plants. To the classical scholar, what a beautiful commentary on the fictitious stories of antiquity are these modern discoveries! He calls to mind the metamorphoses that Ovid describes; the bore, perhaps, of his school-boy life, the elegant amusement of his later years. He remembers how Daphne was turned into a laurel, and Adonis into a flower; the musical stanzas are no longer an empty sound, they are descriptive histories. The thing he has read of is actually so. These transformations, instead of being imaginary exceptions, are the common lot of life in this world. There grows not now a leaf that is not formed from the parts of animals that are dead; there lives not a solitary animal being which has not derived its constituent elements from plants.

Here, then, we are led to a most remarkable conclusion. If the air for thousands of years has remained unchanged, and if these antagonizing processes are all the time going on, equalizing its constitution, it necessarily follows that the amount of vegetable is accurately adjusted to the amount of animal life; the one cannot get the better of the other, for, if it did, the excess would be instantly restrained by its antagonist, and, in this point of view, these two grand forms of life constitute together a splendid automatic or self-adjusting machine. Men talk about the dullness of science; it is only so to those who are unable to follow its developments to their consequences. Where will you find in the whole range of poetry a conception more sublime than this? The two divisions of the world of organization reacting on each other through the medium of the atmosphere—the living against the lifeless, the moving against the motionless; and not only thus influencing each other through that medium, but maintaining its properties forever unimpaired, and ready for action. It is the glory of astronomy to have proved that the planetary orbs, which circle round the sun, under the influences of a pair of forces thus reacting, can retain their movements undisturbed through a coming eternity. And if astronomy has made the splendid discovery that the inorganic world has attained a condition of eternal equilibrium, chemistry has rivaled it by showing that the same grand truth applies to the world of organization. To watch the eternal coming out of the transitory will always strike a reflecting mind with emotions of the highest admiration. The sunbeam—the finger of God—that reaches across the uuknown abysses of the universe in a moment, bringing life out of death, and clothing the objects around us with their many-colored dyes, has extracted this condition of everlasting permanence from a preëxisting transient order of things.

From considering this adjustment of the animal and vegetable kingdoms to each other, we might be led to the idea that each individual in these natural divisions has its counterpart in the other; an idea bringing us into a new relation with inanimate objects. There is implanted deeply in the hearts of all men an instinctive love of natural scenery—forests, flowers, the green grass—and surely such a sentiment cannot suffer from the thoughts now occurring to us. We establish with such objects a relationship, I had almost said a friendship; they become, as it were, a part of ourselves, things essential to our own existence; and that deep attachment we feel to the place of our birth, or our home, finds its apology not alone in natural instinct, or in acquired habits, but also in the highest philosophical considerations. In imagination we might mark off groups in the two kingdoms which are the fanciful representations or counterparts of each other. Perhaps we men, who have to resist the storms of life, may have our representatives in the rugged trees of the forest; the ladies will certainly find their antagonists among roses and other flowers.

From what has been said, you will have gathered how important is the part which oxygen plays in the scheme of Nature. To it is committed the duty of destroying all animal races, and transferring the parts of which their bodies are composed to plants. It begins to discharge this function the moment we begin to breathe, pervading each instant every part of our bodies, bringing on interstitial death, and the continuous removal of particle after particle which it carries away. For there is an incessant change in the substance of all living structures; that which we are to-day differs from that of yesterday and to-morrow, and this untiring agent is all the time at work, assaulting and undermining, nor stopping its action with our dissolution, but going with us into the tomb, until it has restored every particle back to the air. Death is not, as the popular superstition says, a phantom skeleton, nor, as the Asiatics think, a turbaned horseman, who pays his sudden and unwelcome visits. He is this invisible principle in the air which surrounds us, and which is in the very breath we respire.

If thus the duration of individuals and races is determined by the two great systems of forces which have been combined into a self-acting contrivance, it surely is one of the most interesting inquiries in which we can engage, to find in what way so extraordinary a combination has been established. From those remote periods to which we are able to trace the history of the earth, has the same kind of agency prevailed, or have other laws and other self-acting contrivances been resorted to in other times? You see I here assume the doctrine of the geological antiquity of the earth without any kind of hesitation. During two centuries its spherical form was bitterly denied by many very good and well-meaning men. But the truth at last prevailed. And during the last fifty years its age has in a similar way, and on similar principles, been contested. But this, like the former, is now a settled question; neither the one nor the other is any longer open to debate. He who thinks the earth is only a few thousand years old, simply knows nothing about the matter. He who denies its antiquity will also probably deny its figure.

I proceed, then, rapidly with the inquiry in which we are engaged, and would premise that there is no fact better established in all the range of physical science than that of Priestley's, heretofore mentioned, that plants grow at the expense of the atmosphere. I further call to mind the indubitable fact that all coal, whether bituminous or anthracite, is of vegetable origin; that all the great deposits of these carbonaceous materials, occurring in Europe, Asia, Africa, America, and in the islands of the sea, for hundreds of miles in extent, and of unknown thickness, are vegetable matters once formed under the influence of the sunlight, and existing as luxuriant forest-growths—forests that in succession were entombed in the bowels of the earth. There was then most assuredly a time when all this carbon existed as carbonic-acid gas in the air, giving rise to an atmosphere in which, as we know, animal life could not exist. But the sun had charge of the matter, and as centuries rolled by he was extracting that poisonous gas from the atmosphere, effecting its decomposition, as he did for Priestley, bringing forth from it vital air, oxygen gas, and getting things ready for the appearance and continuance of animal life.

I therefore regard, in a philosophical point of view, the period of the deposit of the coal as the great event in the earth's history. Those who are familiar with the details of these things will recognize it as the epoch which parts off a blank solitude on one side, broken by the rude beginnings of low animal life, from that later period, on the other, which is adorned by all the beautiful contrivances of animated Nature, and crowned by the presence of man. The laws of Nature have ever from the beginning been such as they are now. We are fully able to trace the clear relationship between the condition of living things on the surface of the earth and the constitution of the atmosphere; and what chemistry says ought to have taken place in successive centuries, geology tells us actually occurred. Understanding the changing condition of things as respects the air, we could predict the corresponding changes in animated Nature, and the evidence that we are right is engraved on the rocks and stamped on the ocean.

So, therefore, we see that that relation which now exists between animals and plants, and the atmosphere, is an affair that has sprung out of a prior order of things—that there was a time when the constitution of the air was utterly unfit for the support of animal life; that a purification took place through the action of the rays of the sun; and the deposit of coal marks out the great epoch when life of a high order, among air-breathing animals, became a possibility. And is it not interesting to remark how gradually, from a totally different order of things, have sprung those great laws which determine not only the fixity of the constitution of the air, but also the duration of species and individuals; that automatic, self-acting machine in which animal and vegetable life are the opposing forces.

In thus sketching out the course of events as we now know them to have taken place in those ancient times, and in explaining how one system of laws has spontaneously been developed out of another, we cannot avoid making a comparison between the feeble contrivances of men and the means resorted to for the conservation of the world. We are accustomed to look back with admiration to the wisdom of those great men who laid the foundations of this republic, and established a constitution for it; but what would our admiration be if it had been possible for them to have enacted one single law of such simplicity and comprehensiveness, that every other law, by any possibility required in all the contingencies of a thousand years, should have spontaneously sprung out of it? if it had been possible for them, by one legislative act, to have completed and brought to a conclusion all legislation? The good and evil which we constantly see arising in our political assemblies, what are they but commentaries on the want of wisdom and want of power of man? But what is not possible to man is possible to God; and I think it will always elicit from a reflecting mind a tribute of veneration, to know that this great and intricate machine of the universe, with all the millions of beings, living and inanimate, that compose it, with all their affections, attributes, and relations, are sustained and governed according to the original and unvarying intention of their changeless Author; that from the beginning of things, as respects its physical condition, there never has arisen occasion for retouching a work perfect in itself from the first. I am not among those who regard this system of acting through ancient and self-imposed law as in any wise derogatory to the Great First Cause. I appeal to the common decision of mankind, whose admiration of any human contrivance or machine is greater in proportion as the machine is self-acting, performing its effects with rigorous precision, according to the conditions under which it was constructed; but less, if the engineer has from time to time to interfere in order to insure its successful action. I recall that well-known maxim of the law, "Qui facit per alium facit per se"—whoso acts through another, acts himself. It makes no difference in my estimation, in this respect, whether the Architect of the universe himself directly interposed, and compelled such a constitution of the earth's atmosphere as was conducive to the ends he had in view, or whether, under the laws he had imposed on it, the obedient sun proceeded to discharge that task, and put forth his rays with unwonted effulgence, bringing on a great increase in the amount of vegetable life, a great depuration of the atmosphere, the burial of enormous quantities of carbon in the ground, and the gradual assumption by the air of that condition suited to the support of a high organization, and of the life of man. I appeal to the experience of us all—each of the celestial phenomena we witness, the revolutions of the stars, the return of comets, the occurrence of eclipses, each of the changes that happen on earth, the flux of the tides, day and night, summer and winter, the budding of trees and unfolding of flowers, the rise and fall of empires—do they not all take place, not through present and incessant interventions, but in obedience to ancient law? I recall what we all witness as respects the social condition of man, that, according as he advances in intellect, he lives under self-imposed rules, and that his reverence for law is the measure of his civilization; that it is the pride of that civilization to put in the place of an autocrat, dispensing instant rewards and punishments with his own hands, the ideal majesty of the law, which deals out inflexible justice to the good and evil, and makes no distinction of persons; and, reasoning in this manner, from insignificant beings and small things to those which are great, I conclude that a Pure Intelligence will rarely act by intervention, but always through law.

Through that astronomical agency to which I have referred—the action of light exerted during the period of the deposit of the coal—a purification of the atmosphere was effected to such an extent as gradually to enable warm-blooded animals to exist, the temperature to which they attain being directly dependent on the amount of oxygen they take from the air. All animals, from the first period of their coming into existence to the moment of death, are continually, by their respiratory effort, obtaining this gas, so essential to their very existence, and as continually expelling the effete and dead matters of their systems, under the forms of other airs—carbonic acid, ammonia, and the vapor of water. And thus the atmosphere is the source from which our bodies come, and to which they return, continually during life, and, with the exception of their earthy ingredients, totally after death, and the gases that are found in it are at once the agents and objects of the change. Had Priestley realized these things, could he have induced Chemistry by her witchcraft to compel the gas he had discovered to tell its own story, and how it determined his destiny, his imaginative but theological mind would perhaps have recalled the similarity of its own adventurous inquiry with that of the old Jewish king who visited the sorceress at Endor. Awakened by the power of her spell, there arose, from the enchanted circle over which she waved her wand, the form of an old man whose face was shrouded in his mantle. And he said, "Why hast thou disquieted me, to bring me up? To-morrow shalt thou and thy sons be with me."

Some seek for pleasure in the mere gratification of animal appetites, let us rather find it in the exercise of the intellect; and, when spring approaches, let us rejoice in the change, not so much because there is a promise of food, though we should never forget that all these vegetable products, of which so many are destined to delight our tastes, were mortal poisons while they were yet in the air, but chiefly because they are indications that all that is necessary for us as thinking beings is accomplishing. I have told you that the continuance of the life of man is indissolubly linked with the putting forth of the buds of trees. Let the one fail, and the other will speedily stop. Nay, more; as all our intellectual acts can only go on as a consequence of respiration, and the respiration, too, of such an atmosphere as that of our earth, we perceive that our highest endowments are thus connected with things at first sight apparently having no connection with them. And though it is thus the arch-chemist, the Sun, who transmutes a poisonous gas in the air into fruits, and seeds, and flowers; who prepares the vital medium that we breathe, and enables us, therefore, to think and move, shall we not look with veneration, through his more obvious agency, to a silent influence that is beyond? For these products of his action are so many witnesses to us of a provident foresight for our physical and moral wants. There is an authority who has taught us not to disregard such natural emblems. Who is it that has set his rainbow in the cloud, as the pledge of a plighted word? We are surrounded on all sides with similar indications, and are constantly invited to see in each material event a token of intellectual benefit; and if, as we have seen, from a poisonous atmosphere, there has thus gradually been developed, under the agency of that great celestial body, a medium suited to the well-being and conducive to the happiness of man, may we not hope that what has taken place as respects his physical is a type of what will occur as respects his social condition. Who that looks on the events which this year has brought forth[1] —the overturning of thrones and time-cemented institutions, the bloodshed and atrocities of civil wars—who does not recognize that we are entering on an era? The material atmosphere once had a poisonous constitution, the social atmosphere has its poisons too. There is a cry, almost of despair, from the Baltic to the Mediterranean, from the Black to the Atlantic Seas. It is no imaginary nightmare that is oppressing men, but so greatly has the human mind been developed by the advance of knowledge, that it has outgrown the existing order of things. The pressure of that invisible social atmosphere has become too intolerable to be borne; it must be cleared of its impurities and poisons; there must be freedom for thought and freedom of action. The natural change which we have been considering was only brought about after many a convulsion; the moral change must have its catastrophes. But are we not taught, from this evening's reflections, to trust that there is in this too the influence of One far greater than the sun, but of whom the sun is the most noble and appropriate type, who, unaffected by the tempests of the times and the sufferings of men, is steadily shaping the course of events, to bring things at last into a condition suitable for the intellectual as well as the physical well-being of our race?

[1] This was said in 1848, a year of many political revolutions.

THE PHYSICS OF ICE.

By E. LEWIS, Jr.

THREE-QUARTERS of a century ago a cargo of ice was obtained from a pond near the junction of Broadway and Canal Street, in New York, and sent to Charleston, South Carolina, in a vessel chartered by a gentleman of that city. But it was in 1805–'6 that Frederick Tudor, of Boston, inaugurated and laid the foundation of the now immense ice-trade of the United States by shipping, as a mercantile adventure, a cargo to St. Pierre, on the island of Martinique. This cargo, with several subsequent shipments to other West Indian ports, was largely unprofitable. The people to whom it was sent, unfamiliar with its use, knew little of its value.

In 1833, Mr. Tudor sent in the ship Tuscany the first cargo of ice from this country to Calcutta, and thus began the ice-trade of the United States with seaports of India. Several years after that event, the Hon. Edward Everett, then our minister to England, met in London a wealthy and eminent Hindoo, who cordially thanked the American people whom he represented for the great service they had done to his countrymen in shipping cargoes of ice to India. It is obvious that, in our zone of alternate heat and cold, ice is one of Winter's great benefactions. In the healthy preservation of food it is indispensable during summer's heat. In regions where little ice forms, the mountain-snows are economized. Some years since the supply on Mount Etna gave out, and a glacier buried beneath sand and lava was found, and worked as an ice-quarry to supply the necessities of the people. Ice of good quality is now produced by artificial methods, but it is our purpose to develop in this paper some of the physical properties and phenomena of ice, rather than its economic value.

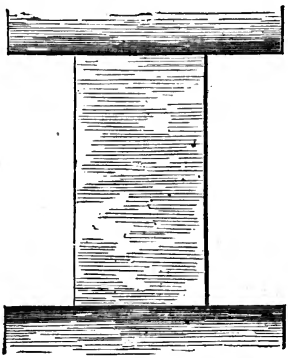
Ice is simply water in a solid state. In ordinary conditions it begins to form at a temperature of 32° of Fahrenheit's thermometer, and this is the well-known freezing-point. Below it the molecules of water become fixed in the grasp of molecular force; above it they are separated by heat, and fall asunder, forming liquid water. But to this law are exceptions, in which water may be cooled many degrees below 32°, still remaining liquid. In glass vessels exposed in open air, water kept perfectly still has been reduced in temperature 15° below freezing, and in a vacuum much lower than this. In this condition there is a "tendency to freeze which is kept in check only by the difficulty of making a commencement," and the process begins by the slightest jar of the water. Fine particles of vapor, or mist, and water in fine capillary tubes, may remain unfrozen 20° or more below the freezing-point. Water thus cooled rises in temperature the instant crystallization begins, by liberation of its heat, and at 32°

becomes solid. But, ice may be chilled to any attainable degree of cold. Prof. Tyndall reduced its temperature 100°, during which process it shrank in volume and became intensely hard. From the blow of a hammer it broke with a vitreous ring.

We often witness the fact that water will not freeze if in rapid motion, although it be much colder than the freezing-point; but in this case will freeze at the bottom where its motion is retarded, forming what is called "ground, or anchor ice." The sandy bottom beneath swiftly-flowing streams is sometimes frozen solid by radiation of its heat to the cold water flowing over it. But no ice will form at the bottom of a pond or lake if the water be at rest; it then forms upon the surface only. The particles of water, as they become chilled to near the freezing-point, expand, become lighter, and continually rise to the surface, where they solidify, forming a roof of ice. This phenomenon opens a most interesting chapter of physical science, and we will presently recur to it.

The freezing-point of water may be changed by pressure, that is, water under pressure will not solidify at a temperature of 32°; nor is it known how great a degree of cold it can resist if a corresponding degree of pressure be brought to bear upon it. The lowering of the freezing-point of water by pressure is one-seventieth of a degree Fahr. for a whole atmosphere. Under a pressure of several thousand atmospheres, ice has been liquefied at or near the temperature of zero; so

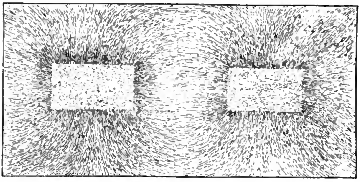
Fig. 1.



Liquid Planes in Ice from Pressure.

that the freezing-point was zero, instead of 32°. The tendency of pressure is, therefore, to keep water liquid, and to render it so after being frozen. The effect of pressure on a cube of transparent ice is well shown in Fig. 1. It is no longer transparent, but is traversed by hazy lines which come into view as the strain is applied. These hazy lines are portions which have become liquid. We have seen that freezing is a process in which water expands in volume. This implies change in its molecular structure, or that the molecules assume new positions. Perhaps the wonderful movement of particles around the poles of a magnet, illustrated by Fig. 2, may suggest the nature of the interior movements which occur in the crystallization of water. Certain it is that the molecules recede from each other and occupy more space than when they lay compacted in the liquid condition.

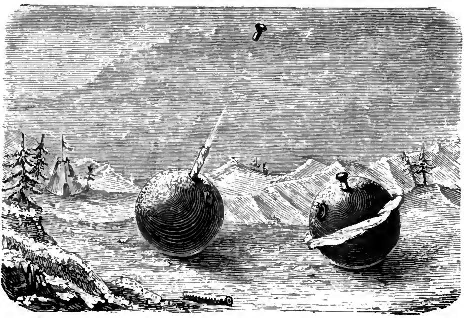
FIG. 2.



MAGNETIC CURVES.

Water expands, in freezing, with a force that is practically irresistible, its increase in volume being about ten per cent. Flasks of copper and iron are broken by it. Rocks are split asunder and disintegrated, and from this cause the freezing of water plays an important part in geological changes. A bomb-shell filled with water and closed by an iron stopper was exposed to frost; in a little time the stopper

FIG. 3.



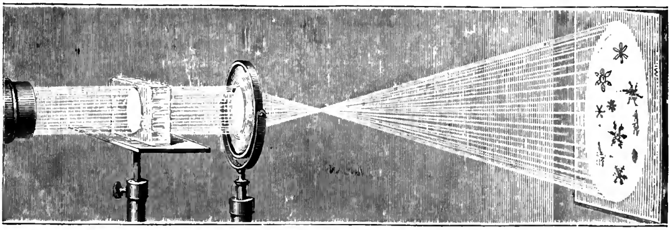
EXPERIMENTS, SHOWING FORCE OF EXPANSION.

was driven out to a distance of several hundred feet, and a mass of ice protruded. In another case the shell burst, and a sheet of ice expanded around the crevice. These tremendous mechanical effects are shown in Fig. 3. In these and similar cases the water may not have been solidified, the tendency to freeze being held in check by pressure, but occurred the instant the pressure diminished.

The expansion of water at freezing is vastly important in its relations to life. Without this property, water in high latitudes would become permanently solid, and the aspect of Nature be one of lifeless desolation. Water, in cooling from a high temperature, contracts in volume, and the cooled particles sink until the mass is reduced throughout to a temperature about seven degrees above the freezing-point, when an important change takes place. Contraction of volume ceases, and expansion begins. The chilled particles remain at the surface from their lightness, and there solidify, while the water beneath, in its deeper portions, may be 7° warmer than the point of freezing. By this means a temperature of water in lakes is maintained adequate to the wants of life.

The structure of ice is crystalline, and the fundamental pattern of the crystals is six-rayed stars. But it is only in entire freedom of molecular motion that crystals attain perfection of symmetry. They form upon the surface of water, when the cold is severe, with great rapidity; but are modified in their arrangement or aggregation the instant the first crust is produced. The additions to the thickness of the ice are always at its underside, and the result is a prismatic form,

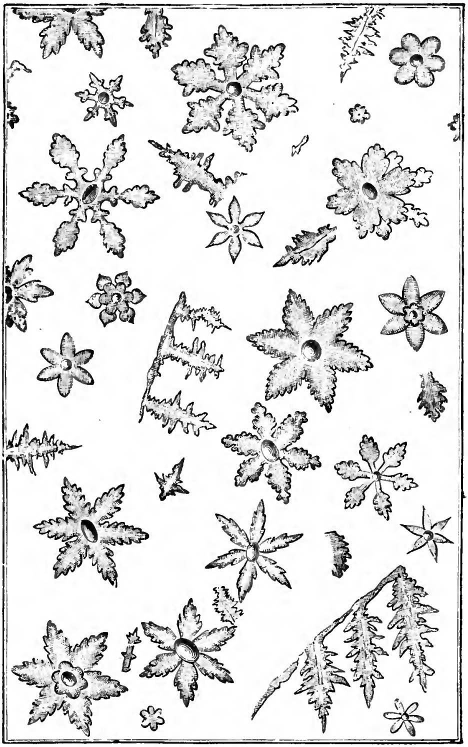
Fig. 4.



Flowers of Ice projected on a Screen.

the prisms growing downward. These prisms are hexagonal in shape, and are so joined at their sides as to present an apparently homogeneous structure. That such is not the case, however, will be seen when we speak of the decay of ice. That the internal structure of ice is upon the stellate type is shown when a small cube of it is dissected by a beam of light. By the heat rays of the beam, the ice is decrystallized—its molecular architecture is taken down, and the result appears in stellate figures of exquisite beauty upon the screen. These figures are areas in the ice which have been liquefied by the beam, which thus throws on the screen an "image of its own work." In Fig. 5 we have magnified pictures of the crystalline structure of ice. They seem shadows of living objects, rivaling fern-leaf and blossom in delicacy and fairy-like beauty. Prof. Tyndall, the great classic on this subject, says, with reason, that, "in the estimation of science, ice bears the same relation to glass that an oratorio of Handel does to the cries of a market-place. The ice is order; the glass is confusion. . . . Nature lays her beams in music." In each complete flower is a little

Fig. 5.



Flowers of Ice magnified.

disk. These are vacuous spots, caused by diminution of volume as the ice is converted to water at each point where a flower is produced.

Ice-structure is not impaired by the luminous rays of a beam, to which it is transparent, but by the dark or heat rays, to which it is opaque. These, arrested in their transition through it, expend their energy in taking asunder the molecules of which it is constructed. They become "our working anatomist," and reveal the interior and otherwise hidden form of ice architecture, shown in the ice-flowers of the figure.

Had the heat-rays which destroyed the ice fallen into water, it would have been heated; but, falling into the cube of ice, and melting a portion of it, no change in temperature occurred. Ice melts at 32°, and the temperature of the water in which it floats is kept steadily at that point until all of it has disappeared. The ices we consume, and the iced drinks for which we thirst in summer, are, at the freezing temperature, 68° colder than the internal organs with which they are brought into contact.

Ice, like other solids, may be cooled and warmed. That which Tyndall chilled 100° could be warmed steadily to the temperature of 32°, and a thermometer would indicate the change; but at that point the process is interrupted—the structure falls into pieces, and not until the mass is entirely liquid can the warming be resumed. From that point, however, it goes on until, at a temperature of 212°, it again ceases, and the molecules of water are separated into vapor.

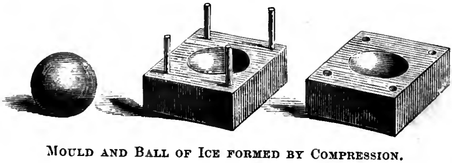
But, in melting the ice by the dark or heat rays of the beam of light, a great quantity of heat was consumed, not in raising temperature, but in undoing what molecular force had done. To simply melt a pound of ice requires 142° of heat, that is, an amount which would raise the temperature of a pound of water 142°. Now, this is the equivalent of the molecular force exerted in solidifying the water, and the mechanical value of the two forces is the same. Expressed in figures, it is equal to lifting the same pound of ice 110,000 feet high. The mere melting of 20 pounds of ice, a quantity received daily by many families, is equivalent, in mechanical force, to lifting nearly 1,000 tons' weight a foot high, or to lifting two persons weighing 300 pounds 1,000 feet higher than the summit of Mount Washington. We may thus realize the enormous display of energy along the line where heat and molecular force contend for the mastery.

The transition of water to ice, and of ice to water, produces important changes in the temperature of surrounding objects. We are often made painfully sensible of the chilling influence of the atmosphere when its heat is rapidly abstracted in the melting of large masses of ice and snow. But the reverse of this takes place in freezing. The crystallization of water is attended with an elevation of temperature. The heat which vapor carries with it in its aërial journeys is liberated when those vapors are transformed into flakes of snow. The expression we often hear when a storm in winter is imminent, that "the cold is too great for snowing," is true enough. The air is made warmer when snow-flakes begin to form, and the temperature is higher than it would otherwise be while snowing continues. In this way the formation of ice and snow modifies and softens the temperature of arctic winters; and the blossoms which open with the spring-time are not more significant of milder airs than are those which are born of frost and vapor, and expand their petals to the winter's tempest. Snow-flakes are stellate in form; the molecules of vapor in crystallizing aggregate in six-rayed figures, but in endless diversity of patterns. Captain Scoresby figured 96 of these, beautiful illustrations of which are shown in the plate. And Nature is profuse of these "frozen flowers." On mountains, and amid solitudes of the North unseen by man, she scatters them as she does those which waste their perfume in the desert. The delicate lace-like figures which follow the touch of frost on the window-pane are of the stellate type, but, being modified by disturbing influences, develop into gorgeous patterns.

Ice, when decayed, is weakened and becomes soft throughout, scarcely more compacted than snow. By rains and mild weather of spring, ice on our Northern lakes is thus impaired. In this condition it is said to be "honey-combed;" and, while yet many inches in thickness, and apparently solid, is unsafe to travel over. The foot of a horse will pass through it, displacing merely the portions beneath, and without fracture of the surrounding parts. This arises from the prismatic structure already noticed; and it is along the lines of adhesion of the prisms that the ice first yields to the invasion of heat. When thus weakened, it will sometimes disappear from the surface of a lake by a few hours of heavy storm, or, if any portion remain, it will be in the form of crystals, thoroughly permeated by water. So rapidly has it vanished in many instances from lakes, that its sinking was insisted on, but it is now known that it disintegrates and disappears by internal liquefaction.

A most interesting and important property of ice remains to be noticed. We refer to that by which it may be moulded into almost any form by pressure. Cubes of solid ice have been pressed into balls, cups, rings, and other shapes, showing its extraordinary plasticity. At a temperature of 32°, ice is by no means a rigid substance, but readily yields to pressure. Placed in the cavity of a mould (Fig. 6), it is broken into innumerable fragments as pressure is applied. It has

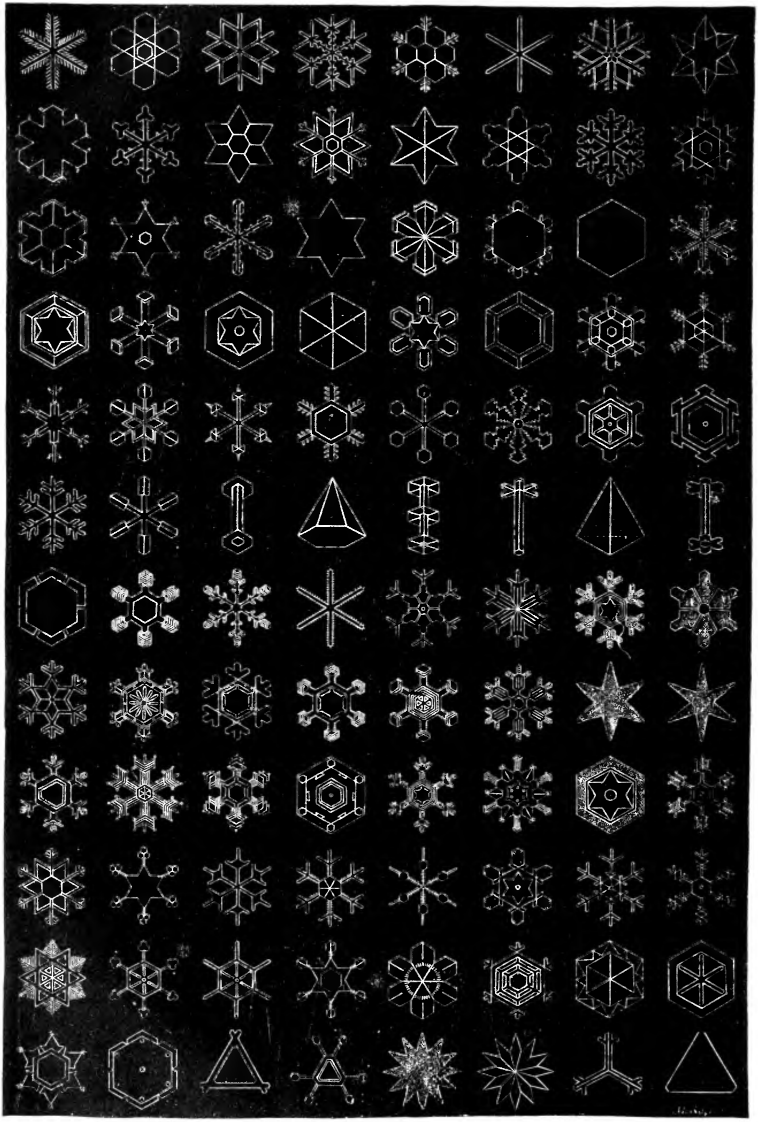
FIG. 6.



MOULD AND BALL OF ICE FORMED BY COMPRESSION.

been shown, however, that, unless the crushing be sudden, the ice is not reduced to a granular or powdery mass, but maintains its cohesion while it undergoes change of form. During the process a portion of the ice becomes liquefied, and the water escapes, carrying with it the heat liberated in the liquefaction, but the portions remaining are moist, and at each point of contact directly adhere together by freezing of the moisture. This refreezing takes place throughout the mass,

Fig. 7.



Ice-Flowers.

molecule to molecule, particle to particle, mass to mass, and a ball or other figure of solid ice is the result. If there be no moisture, there can be no refreezing until moisture is produced or applied. Thus pieces of ice below the freezing temperature will not adhere because the surfaces are dry. The same is true of dry, granular snow in very cold weather—only by long-continued moulding and pressure in the hands can it be compacted. But in this case some liquefaction has been produced, and then the surfaces in contact freeze together. Snow, in the upper Alps, often covers gorges in the glaciers, and if moist can be trodden into bridges sufficiently compact to pass safely over.

This property of ice and snow Prof. Tyndall calls regelation. It was discovered by Faraday in 1850, who found that moist surfaces of ice adhered if brought together. This occurs under water as well as in the air; at summer heat, and beneath water so hot as to be painful to the hands. The phenomenon may be explained in this way: If we hold in our hands two cubes of ice, their outer surfaces are exposed to the atmosphere, and, if it be warm enough, some liquefaction at the surfaces takes place, and they become moist. Now, if the cubes be brought together, two of the outer surfaces become inner ones, and the moisture, chilled to the temperature of the ice, freezes, and the two cubes become one mass. It is because the molecules of ice may be continually crowded into new positions that the mass may be changed in form without its continuity being broken. A slab of ice placed in a suitable position will bend by its own weight. In this case the molecules throughout undergo gradually a change of position; but, if the stress be too rapidly applied, fracture occurs.

All the properties and phenomena of ice which we have considered, and in a marked degree that of regelation, are shown in the growth and movement of glaciers. In these we see the development of ice on its grandest scale. Equally in structure and form in molecular and molar motion they are an expression of energies that are irresistible and sublime. "To produce from aqueous vapor," observes Prof. Tyndall, "the little mass of snow which a child can carry, demands an exertion of energy competent to gather up the blocks of the largest stone avalanche I have ever seen, and pitch them to twice the height from which they fell." Who, then, shall estimate the potential energy of the great ice-rivers of the Alps, or of the glaciers of the Arctic Zone?

The motion of the Mer de Glace, and of other glaciers, is so slow as to be ascertained only by persistent observation, or by careful measurement. In 1827 a hut was erected by Huji on the glacier of the Unter-aar for purposes of observation, but the hut was found to move down the valley. In fourteen years it was nearly a mile below its first position. In 1820 three mountain-guides were plunged by an avalanche into a gorge of a glacier on the side of Mont Blanc. After a burial of forty years in the ice, they were found several miles below the spot where they were lost. The velocity of a glacier depends chiefly upon the angle of slope over which it moves. The hut of Huji moved 336 feet in a year. But the motion in different portions of a glacier is very unequal, slow at the margins and at the bottom where friction retards progress, but may attain a velocity of three feet or more in a day at its line of most rapid flow. It has been estimated that the ice-sheet which covered New England at its greatest development in the glacial age may not have advanced more than a foot in a week, a mile in a century.

A question has arisen, Do glaciers slide upon their beds? It seems to be conceded that sliding takes place to a limited extent. It may occur where the uniform flow of the glacier is interrupted, and separation of its parts produces crevasses, as along its margins, and over an uneven bed. We are chiefly concerned, however, with the motion which has its origin in the physical properties of ice.

The flowing of a glacier may be quite independent of its sliding motion, if such it has. It flows because of its plasticity, its molecules undergoing incessant change of position as they do in ice under pressure, and regelation goes on throughout the mass. By these means its cohesion and continuity are maintained.

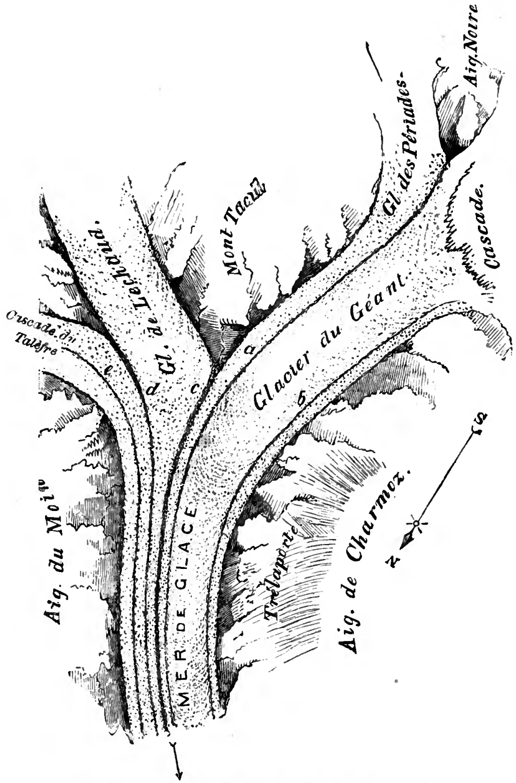
It is often stated that the temperature of the interior of a glacier must be much below the freezing-point. This is probably an error, the temperature throughout differing but little from 32°. The pressure, indeed, may be enormous, and portions of the ice be liquefied by it, but the water which is "ice-cold" escapes through innumerable fissures, and the freezing-point is not lowered by the pressure, as it would be if the water of liquefaction did not escape. The constant flowing of a glacier necessitates unceasing supply, and its source is found accordingly in that zone of elevation where snows accumulate. The snow-fall of which the glacier is born implies vapor clouds and condensation, and equally evaporation, the proximity of a warm climate and expanse of ocean. Hence it is inferred that cold and warm climates were contiguous during the age of glaciers, as they are at this period of their decline. Glaciers relieve the land of accumulating snows as streams do of excess of waters. But for these, mountains reaching above the line of perpetual frost would become buried, and the "ocean piled upon the land." But such a process has its limitations in the economy of Nature.

The snow which falls in great volume upon mountains is a dry powdery mass, and cannot be consolidated until some liquefaction has taken place. This quickly occurs. Through the clear air of great altitudes the sun's rays fall with intense power upon objects, even while the temperature is at freezing in the shade. Portions of the surface snows are thus melted, the under portions are moistened by the percolating waters, and regelation begins. The phenomenon of the snow-ball is here reproduced on a gigantic scale, differing in this:

in the one case liquefaction is produced by pressure, in the other by solar heat. Gradually the under-layers become incipient glacier-ice.

Movement of the mass originates in its gravity, and the direction must be down the slope on which it lies. Many streams in this way blend into immense rivers of ice, often several hundred feet in depth. The snow when first consolidated is filled with air-bubbles, and is white and opaque. Its whiteness disappears by expulsion of the air-

FIG. 8.



SHOWING THE CONFLUENTS OF THE MER DE GLACE.

bubbles from pressure as the glacier moves down the valley. At its termination the ice is transparent, and its exquisite tints of blue indicate the extreme minuteness of the reflecting surfaces which linger in it.

The physical properties of ice by which it flows need not be restated further than to mention that the opinion of Prof. Forbes, that it flows as a "viscous substance," is not accepted. Wax, we may say, is both plastic and viscous, and yields equally to pressure and to tension. Ice yields to pressure, but not to tension. It cannot be stretched. Glaciers maintain their cohesion under pressure as plastic bodies, but, wanting viscosity, they break into profound chasms where the tension is great. In ice, therefore, one property is wanting to render it a viscous substance. In Fig. 9 is beautifully shown the opening of crevasses on the margin of a glacier, where the flow is retarded by friction. A like phenomenon occurs when a glacier falls in a cascade over a precipice. Then chasms appear of startling

Fig. 9.

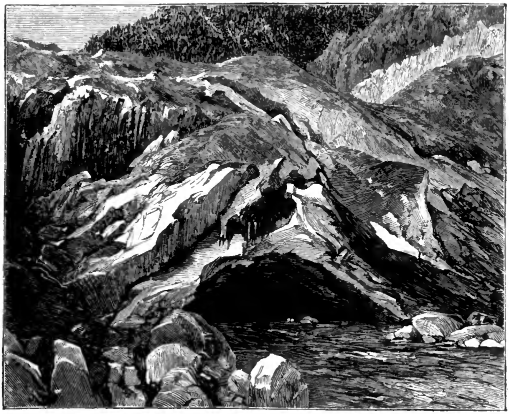
Marginal Crevasses.

depths, and gigantic blocks of ice are thrown into the wi dest confusion. From the chaos come sounds which indicate what is going on below. The nether air is filled with echoes from the murmur or roar of water, the falling of bowlders, and crashing of ice. At the foot of the fall the broken fragments of ice are crowded together, become solid by regelation, and the mass moves on.

The terminus of a glacier may be many thousand feet below the limit of perpetual snow before its disintegration is complete. But the wonderful fabric falls at last, as heat destroys its molecular framework, and is lost in the turbid flood which forever pours from beneath its portals. But the sediment of the incipient rivers thus formed was no part of the crystalline structure, for crystallization casts out impurities, and gathers neither soil nor stain in its beautiful textures. The sediment arises from abrasion of solid matters held in the under-surface of the glacier upon the rocks of its bed. In Fig. 10

is shown the source of the Arveiron and the sublime view of the foot of the glacier whence it issues. Of this M. Rendu says, "It is a vast portico more than a hundred feet high, let into an immense *façade*, and surmounted by lofty pyramids of ice. Nothing is more astonishing than this work of the elements, of which Nature alone has conceived the plan, and achieved the construction."

FIG. 10.



SOURCE OF THE ARVEIRON.

Ice presents, under pressure, many phenomena of great interest other than those mentioned, and to which we can only refer. The prismatic or crystalline form, so beautifully developed in lake-ice, is more or less destroyed in glaciers by the unceasing fracture and regelation which takes place from pressure, and the mass assumes a granular structure. The same phenomenon occurs with ice in a mould. In glaciers are veins which reflect a deeper tint of blue, indicating where from local causes greater or more persistent pressure has cleared it of bubbles of air. Glacier, and probably other ice, under similar conditions of pressure, becomes laminated, or develops planes of cleavage, resembling those of slate-rock in the quarry; and this structure is shown in the decay of the ice, as its prismatic structure is shown in the decay of that on lakes and rivers.

By the physical properties we have noticed, ice becomes a dynamic agent of tremendous power. The play of forces and plasticity of structure which make it a toy in the laboratory, have changed the aspects of Nature, and modified the surface, as they have the distribution of life, upon a large portion of the globe. Rocks are broken by its expansive energy, but they are also crushed by its weight, and ground to dust in its irresistible motion. A sheet of ice a mile in thickness rests upon the bed, over which it moves with a pressure of more than 260,000 pounds for each square foot of surface, and many such as this covered the old glacier-regions through an unmeasured period of time. In their movement lakes were excavated, water-courses changed, and landscapes cast into innumerable forms of beauty. We utilize the results. Our forests and our harvests grow upon soil ground in the glacial mill, and we build our cities on mounds of glacial rubbish. Nor can we fail to realize that here, as elsewhere in the phenomena of Nature, there is a ministration to our conscious life, as there is an appeal to our sense of beauty, and that, whatever form it may assume, whether of the feathery spangle which rocks upon the waves of air, or the profound glacier that buries a continent, ice is Winter's benefaction.

THE DEVELOPMENT OF PSYCHOLOGY.

II.

J. S. Mill—Bain—Spencer.

GREAT as were the services of Mr. John Stuart Mill to Philosophy in general, and Psychology in particular, we cannot ascribe to him any notable advance in psychological doctrine, or in the conception or application of psychological method. In doctrine, his chief contributions were the restatement, in a form adapted to the changed conditions of the controversies, of Berkeley's theory of material, and Hume's theory of mental, existence. But neither the psychological theory of mind nor the psychological theory of matter contains any new principle, or exhibits any new way of applying old principles. In constructive method, he could get no further than Brown's half-century-old "chemistry of the mind," and though he earnestly recommended the St. Andrew's students to make the acquaintance of Physiology, as supplying to Psychology the principles of predisposition, habit, and development,[1] he never made the smallest use of these principles himself, and had not a single word to say in favor of Mr. Spencer's use of them.[2] That he still traded on the old conceptions is evident from his metaphors: the "thread of consciousness" is a decided advance on Locke's "gang of ideas," but he shies at Prof. Masson's "organic union" of states, and prefers to connect them by an "inexplicable tie."[3] Mill, in fact, was above all things a logician, and whatever he accomplished in the sciences was in virtue of his clear perception of the extent of a principle, the limitations to which it was subject, and the conditions under which it could be most fruitfully ap-

[1] "Inaugural Address," pp. 61, 62. [2] "Dissertations," iii., 99, note.
[3] "Examination" (third edition), pp. 256, 257.

plied. His services to psychological method were of this order, and therefore belong rather to the logic of science than to the history of Psychology. But, as his luminous exposition of the logical *status* of the "laws of mind"[1] had an unquestionable influence on the most systematic application of these laws yet made, in the comprehensive work of Prof. Bain, it will be proper to inquire whether this advance too had its antecedents in the physical sciences.

Mill's logic of psychology is characteristic. Like all his doctrines, it has a positive and an hypothetical part—the hypothetical admitting almost all that his opponents of every school would assert, and the positive so stated as if those admissions had not been made. The positive aspect of it may be embodied in three propositions. Psychology is a *science*, because the facts of mind present certain uniformities of succession, which we call laws. It is an *independent* science, because its laws are ultimate, and cannot be deduced from the physiological laws of our nervous organization. Finally, this science has certain *limits*, which are stated, however, with a vacillation and obscurity very far from usual with so clear and resolute a thinker, but which appear to be: that sensations of one sense cannot be resolved into those of another; that "the other constituents of the mind, its beliefs, its abstruser conceptions, its sentiments, emotions, and volitions," have probably not been generated from simple ideas of sensation; and that, even if this can be proved, "we should not be the more enabled to resolve the laws of the more complex feelings into those of the simpler ones." In the hypothetical part (which has been much more strongly expressed in the later editions of the "Logic," though without any corresponding alteration of the positive part), Mill is quite prepared to admit that "the laws of mind may be derivative laws resulting from laws of animal life, and that their truth, therefore, may ultimately depend on physical conditions." But the probability of this genesis being shown, he apparently regards as so remote that it is not worth while to take the antecedent physical conditions into account except as disturbing agencies.[2] He refuses to see that if the evolution of the higher forms of life from the lower can be made out, we do not say as an induction, but even as a good working hypothesis, the foundations of Psychology will be subverted, and it will be changed from what we may call a statical into a dynamical science.

Mill belonged, less by age than by precocious mental development, to a generation which found in him its perfect scientific, and in Mr. Carlyle its most consummate literary, expression. In literature, it turned with reverted eyes to an ever-receding golden age, and wrote histories; in science, the impulse was rather to widen, clear, and connect the old paths, than to strike out in new directions—to get round obstacles, than to tunnel them. "Reaction" is so ready a spell to

[1] "Logic" (sixth edition), ii., pp. 431, 442. [2] "Logic," ii., 433.

conjure meaning out of facts by pretending to put an explanation upon them, that we will not ascribe the critical mood of the last generation to mere revulsion from the profuse hypotheses of the period when Chemistry promised to reveal the secret constitution of Nature; but, clearly, after a time of discovery and accumulation of facts, there comes the necessity for arrangement, classification, method, and the logician takes the place of the discoverer. To this work the generation of 1820–1850 set itself in no scholastic spirit, and one of its first achievements in the new field was Herschel's picturesque and elevated "Discourse."[1] Ardent and imaginative as is that fine essay, it is nevertheless essentially logical. Four of his nine "rules of philosophizing" were converted by Mill into the experimental methods, and thus made a part of the logic of proof; his conception of a law is predominantly that of a generalization which seems to imply no inductive leap; and he appears to look for the openings to future discovery in the purely analytic direction of finding some more general laws of which the laws already discovered are cases. So faithfully did the work embody the tendencies of the period that its phraseology at once became classic, and its ideas of cause and law the commonplaces of science. They certainly formed a large portion of the mental pabulum of Mill, and are reflected, though with infinite widening and clarification, in the "System of Logic." We have already said that his four "methods" were but four of Herschel's "rules;" Herschel's "presumed permanence of the great laws of Nature" appears in Mill as the statement that "the uniformity of the course of Nature is the ultimate major premise in all cases of induction," and the relations of induction and deduction, the value and test of hypotheses, the nature of empirical laws, and the analysis of cause—are all striking *aperçus* which Mill pursued to their limits on every side, and thus was able to give to the exposition of them systematic completeness. All these conceptions, as being important parts of the logic of science, belong equally to the logic of psychology, and, if their statement in reference to mental science is due to Mill, the statement of them in reference to science generally is due to Herschel. But we are here more concerned to point out that the scientific conditions laid down by Mill as defining the logical *status* of psychology belong to the type of physical investigations of which Herschel was an early representative. The definition of science as having for its subject "uniformities," the description of the independence of a science as arising out of the irreducibility of its laws to other laws, and the exposition of the limits of scientific inquiry—all find their prototypes in the "Discourse." Here again, therefore, the advance in Psychology, though only logical, had its initiative in the physical sciences.

The rate of change quickens as the type of social structure rises, and the progress made by Psychology within the present generation

[1] "Preliminary Discourse on the Study of Natural Philosophy," 1830.

is not only far greater than has been before made in any period of equal length, but greater than has been made since the foundation of the science. The large acquisitions of new facts, the faithful description of phenomena, the reduction of them to law, and the investigation of the physical "sides" of mental products, which we owe to Prof. Bain, and the application to mind of the revolutionary principle of development, and the inclusion of it within the larger philosophy of evolution, which we owe to Mr. Herbert Spencer, have changed not only the aspect but the constitution of Psychology. Like all the previous advances we have recorded, the developments due to both of these distinguished psychologists have had their dynamic in the subsidiary sciences.

Mr. Bain describes his work as being "the first attempt to construct a Natural History of the Feelings, upon the basis of a uniform descriptive method," and the characterization is just. All preceding surveys of the mind had been undertaken to establish a doctrine, as by Hobbes; to refute a theory, as by Locke; to prove an hypothesis, as by Hartley; or to furnish analytical justification of a foregone conclusion, as by the elder Mill. Mechanics, Natural Philosophy, and Chemistry, having exhausted their constructive impulses on Psychology, it was reserved for Mr. Bain to adopt a method which makes no presuppositions, rests on no hypothesis, and conducts to no necessary conclusions—the method employed in the organic sciences in their undeveloped state. The natural history "method" is very old. The first full-blown specimen of a naturalist, whose reputation has reached posterity, appears to have been Solomon, and of him it is said that "he spake of trees, from the cedar-tree that *is* in Lebanon even unto the hyssop that springeth out of the wall: he spake also of beasts, and of fowl, and of creeping things, and of fishes."[1] Linnæus was even more comprehensive, and added minerals to plants and animals; but with him the differentiation of science and accompanying specialization of method begin. The first great classifier himself constituted Botany a separate science; Haüy followed with Mineralogy; the discovery of Oken (or Goethe) and the theories of St. Hilaire founded Comparative Anatomy; Comparative Physiology issued out of its sister science; and morphological and functional divisions of all these sciences were successively established. With such advances in classification, the natural history method becomes immensely more complex, but its character is fundamentally the same—that of description. We cannot better exemplify this than by quoting the words of Dr. Carpenter. Contrasting him with the "enterprising discoverer," the horticulturist, and the breeder, he says that—

"The philosophic naturalist. . . . aims to reduce the number of species, by investigating the degree of variation which each is liable to undergo, the forms it assumes at different periods of its existence, the permanent characters by

[1] "First Book of the Kings," iv. 33.

which it may be distinguished during its whole life, the habits which are natural to it, the degree in which these may be changed by the influence of circumstances; and, in fine, he endeavors to become acquainted with the *whole* Natural History of a reputed species, before separating it from another to which it may be closely allied."[1]

The "philosophic naturalist" plainly requires just so much philosophy as is implied in keeping his eyes open, and, indeed, so long as species were believed to be separately created, and organic characters could be only correlatively and not genetically explained, there was nothing else for him to do. Natural History before Darwin was like Natural Philosophy before Newton; its inductions were incomplete, and the deductive procedure which could alone raise its constituent groups into sciences was impossible. It was at this stage in the development of Natural History that Mr. Bain took up its method, and set about applying it to the "Feelings." Its power in the hands of a keen and dispassionate observer is indisputable, and the two instructive volumes which contain Mr. Bain's systematic exposition are at once a treasure-house of observations of priceless value, and such a compendious generalization of mental facts of all orders into laws as doubtless marks the climax of the method. But it is fundamentally unscientific. If it be true that the higher forms of life and mind have been evolved out of the lower, then the most resolute introspection, and the most cutting analysis, with the help of stray observations of children, and some patient experimenting on animals, will go no appreciable distance in discovering mental constituents which may have had their origin in an indefinitely remote past. That this is not only a necessary result of the "natural history method," but that it has in point of fact resulted in Mr. Bain's treatise, it may be well to make clear. To keep the analogy in view, we again quote from Dr. Carpenter. "The naturalist," he says—

"endeavors to simplify the pursuit of his science, by the adoption of easily-recognized external characters, as the basis of his classification of the multitudinous forms which he brings together; but such can only be safely employed when indicative of peculiarities in internal structure, which are found to be little subject to variation, and which are not liable to be affected by the influence of physical causes."[2]

Now, such an endeavor to simplify, by the adoption of easily-recognized external characters as the basis of his classification, is a feature prominent in the fore-front of Mr. Bain's work. The mode of diffusion of an emotion, the institutions it generates, and its peculiarities as a state of consciousness—all of them the most manifest characters of the emotions—are avowedly adopted as bases of classification.[3] That easily-recognized external characters are not always "indicative of

[1] "Comparative Physiology" (fourth edition), p. 632.
[2] *Op. cit.*, p. 633.
[3] "Emotions and Will," *first* edition.

peculiarities in internal structure," has been shown by Mr. Spencer, and is indeed a corollary from the theory of development.[1] Mr. Bain's method is therefore misleading from its contracted range, but we must here record, as part of our history, its very great advance on the still more incomplete methods of the older psychologists.

Mr. Bain's other contributions to Psychology are connected with the recent development of one of the sciences whose general method he appropriated. The physiology of the nervous system was of late foundation. Vesalius, Fallopius, Vieussens, Boerhaave, and Willis, had indeed assigned the special functions of certain organs (as those of the senses) to their appropriate nerves, but even in the middle of the eighteenth century the great Haller could deny the existence of any nerve which did not possess the double function of sensation and motion. Whytt and Prochaska, in 1768 and 1800, made observations on reflex and spontaneous movements, and decisively raised the question of the mode of action of the nervous system. In the first quarter of this century Sir Charles Bell established the existence of two great systems of nerves, with different functions, and thus revealed a definite mental mechanism. A few years later Dr. Marshall Hall (or some one else) discovered the independent action of the spinal cord, and helped further to determine the organic conditions of mental activity. His contemporary, Müller, went so far as to assert that the spinal cord was the centre or source of *all* motor power. At this point Mr. Bain came into the field. Appropriating the discovery of Hall, he was the first among psychologists to attempt systematically to elucidate the spontaneous movements, as no less a part of the phenomena of mind than those of consciousness. Combining Bell's discovery with a hint of Müller, he introduced the first organic modification into the association psychology by his theory of the brain as a fountain of force and not merely the passive instrument of impressions. This theory has led him, not only to take into account the secondary mental states generated by the bodily organs, but to trace genetically the origin and growth of voluntary power, and thus to constitute a separate department of Psychology by the analysis of volition, which had previously been the victim of introspection. It has also led him to devote a section to "constructive association," which could have no place so long as there was recognized in the mind no power of original construction. The tendency to materialize the mental agencies—the assumptions that nerve-force is of the nature of a current, that it moves in diffused waves, that associations are generated by shocks—are consequences partly of the introduction of the same new element. They are consequences also of that assumed correlation of the mental and nervous with the physical forces which Mr. Bain has, in his later editions, done much to prove and illustrate.

"If Mr. Herbert Spencer had no other titles to fame, he would

[1] "Essays" (second series), p. 125.

still be the greatest of psychologists. The vast constructions of his 'First Principles' will ever be a monument of his extraordinary powers of generalization. His designed organization of the Social Science opens up the prospect of intellectual acquisitions in the future to which the past may furnish few parallels. But the 'Principles of Psychology' will still remain, in its symmetrical completeness and perfect adequacy to the subject, at once the most remarkable of his achievements and the most scientific treatise on the Mind which has yet seen the light. Its publication in 1855 did not make a sensation. The persistent efforts of Mill had not yet succeeded in stemming the muddy tide of the prevailing scholasticism. The bastard Kantism of Hamilton did duty for metaphysics, and the Common-Sense philosophy of Reid, with the common-sense left out, usurped the place of Experimental Psychology. Experimental Psychology was, as usual, busy with analysis, and had no eye for the merit of an imposing synthetical effort. Mr. Spencer's work had accordingly a chill reception. Greeted by the aristocratic metaphysicians with a few words of courtly compliment, but treated practically with supercilious disregard, it was received by psychologists of the Association school with hardly more favor than the snarling approval with which a Constitutional Whig views the entry into the Cabinet of a Birmingham Radical. Mr. Spencer was ahead of his generation, and paid the penalty of his prescience in twenty years of neglect. But now the wheel is coming round. The bovine British public, constitutionally disposed indeed to apathy, but drugged into a leaden slumber by its medicine-men, is at last awakening to the fact that the peer of Bacon and Newton is here. Writers of all schools are hastening to define their position with reference to the Synthetic Philosophy." A younger generation has grown up, with minds unhardened by the limitations of obsolete Sensationalism, and inclined rather to a somewhat undisciplined acquiescence in what the Germans call "world-shattering," that are also world-constructing, theories. But "whatever part of his philosophy may be transitory, Mr. Spencer's present influence is indisputable; and, since the lamented death of Mill, no one can now contest his claims to the philosophic supremacy in these islands. That supremacy rests mainly on his Psychology." Cosmological speculation has been so long out of date that we are hardly yet able to incorporate his "first principles" as a vital and vitalizing part of our mental acquisitions. Sociological inquiries are just coming into fashion under the dusky auspices of the "savage races;" but the Social Science, though undoubtedly destined to play a great part in the immediate future, still wants an audience, except for sanitary discussions in autumn among peripatetic philanthropists in provincial towns. But Psychology, at least, the kind of thing found in Reid with an infusion of Hamilton, has long formed part of the higher education in Scotland; and at one of the English universities the hash of cosmology, metaphysics, logic, and ethics, named Aristotelianism, yields under pressure some small psychology. Besides being, therefore, in whatever rudimentary forms, a pet academical study, much encouraged by philosophically-minded Heads, the science itself is vastly further advanced than any of the mental sciences, its province is tolerably well defined, in the statement, at least, of its main problems the most opposite schools agree, and both likewise agree in the tests to be applied to their solutions. A pretender to psychological discoveries has accordingly a decided advantage over his brother discoverer in the more embyronic mental sciences in so far that, if he is not out of sight ahead of his generation, he can secure a competently-instructed audience, eager and, on the whole, capable to decide on his pretensions. The extreme fascination of Mr. Spencer's theories, and doubtless their fundamental truth, have obtained for him a large *clientèle;* and the position of the philosophy of mind as the foundation of all other philosophies, social, ethical, æsthetic, and political, has created channels through which his characteristic ideas have percolated in all directions. Such a supremacy as this could only have been gained, if our history of the parallel development of the physical and mental sciences be exact, by a substantial identity of the method and unity of the principles of the synthetic psychology with those of the last-developed organic and inorganic sciences. We shall see that this is the case.

Mr. Spencer's numerous psychological advances may be grouped in two divisions; the application to mind of the theory of development, and the connection of psychological evolution with evolution in general. The last edition of his work also incorporates Mr. Darwin's law of natural selection in the explanation of the emotions, but this may be regarded as simply an extension of the development theory. In the working out of both principles, Mr. Spencer has followed the lead of the physical sciences.

Before it could be discovered that species were evolved from one another, it had to be discovered that there were among them fundamental kinships. The foundation of the comparative sciences was the beginning of the movement, and we suppose that Goethe's "Sketch of a Universal Introduction into Comparative Anatomy" may be regarded as striking the first note. Thirty years' further research reduced the skull of all vertebrate animals to a uniform structure, and determined the laws of its variation. In 1820 Audouin partially succeeded in filling up the chasm between insects and other animals. In 1830 Laurencet and Meyraux assimilated the structure of mollusks to that of vertebrates. Out of these discoveries an internecine war arose between the schools of Cuvier and Geoffroy St.-Hilaire, the former contending that the structure and functions of animals should be studied in the light of final causes, the latter setting up their analogies as the only safe guide. And out of the struggle came the new philosophy. "*The principle of connection*," says Whewell, "*the elec-*

tive affinities of organic elements, the equilibrization of organs—such are the designations of the leading doctrines which are unfolded in the preliminary discourse of his" (St.-Hilaire's) "'Anatomical Philosophy.' Elective affinities of organic elements are the forces by which the vital structures and varied forms of living things are produced; and the principles of connection and equilibrium of the forces of the various parts of the organization prescribe limits and conditions to the variety and development of such forms."[1] Now for the first time we hear such phrases as "unity of plan," and (more significant still) "unity of composition." Then came Von Baer's law of progression of structural development from the general to the special, afterward extended to functional development, and giving rise to the conception of the specialization of functions. Out of this, too, arose the term "evolution," and, though confined to organic development, implied an advance in generalization. The mere mention of such further advances as are implied in the establishment of the functional identity between the contractile tissues of plants and those of the higher animals; in the use of the phrase "psychical powers" to designate the sensorial and mental endowments of animals; in the proof of the absence of specialized sensibility among the lower tribes of animals, and of the hereditary transmission of certain characters acquired under the influence of *external* circumstances; in the parallel traced between the progressive complication of the psychical manifestations during the early life of a human being, and the gradual increase in mental endowment to be observed in ascending the animal scale[2]—may serve to indicate the conceptions forming the matrix in which a philosophically constructed Psychology was to be moulded. How great a revolution had taken place in biology, and how far we have now got from the natural history method, may appear from Prof. Huxley's definition of "zoological physiology," which, though made some years after the first publication of the "Principles of Psychology," at least points out the direction in which thought had been moving. He says:

> "It regards animal bodies as machines impelled by certain forces, and performing an amount of work, which can be expressed in terms of the ordinary forces of Nature. The final object of physiology is to deduce the facts of morphology, on the one hand, and those of distribution on the other, from the laws of the molecular forces of matter."[3]

With a prescient insight into the future of science which has probably few parallels, Mr. Spencer founded his Psychology on the hypothesis of development. To all but a few deep-thinking observers there can have seemed few signs in 1855 that that hotly-disputed theory was ever likely to be in the ascendant. The exposition of none of the

[1] "History of Inductive Sciences," iii., 504.
[2] *See* Carpenter, "Comparative Physiology," *passim*.
[3] "Lay Sermons," pp. 106, 107.

organic sciences that we know of had yet been based on it, and its application to mind was undreamed of. But with a confidence in the intuitions of reason which is one of the clearest attributes of speculative genius, and which may have its analogue in the statesman in the nerve to take the vessel of the state over a bar, Mr. Spencer assumed the provisional truth of the theory, and it might be difficult to exaggerate the extent to which his exhibition of it in Psychology has contributed to its establishment.

It was first requisite to find a generalization on which to base a synthetic Psychology. The assumption being made that mind and bodily life are but subdivisions of life in general, it was required to seek out some characteristic common to both—some characteristic of vital actions in general, and distinguishing them from non-vital actions. Applying a method which Prof. Stanley Jevons has omitted to note in his "Character of the Experimentalist," Mr. Spencer arrives at a definition of life of which the essential point is that it implies a correspondence between life and its circumstances. Here is the first notable advance—the inclusion of the environing world in the definition of the science of mind; and in this is contained the germ of Mr. Spencer's later differentiation of Psychology and circumscription of its province.[1] If correspondence with the environment is the *differentia* of life, it is almost an identical proposition to assert that the *degree* of life will vary with the completeness of the correspondence and the complexity of the environment. An ascending synthesis accordingly finds the correspondence at first direct and homogeneous, then direct but heterogeneous, as extending in space and in time, and as increasing in specialty, in generality, and in complexity. Along with the all-sided development thus going on in the correspondences, there goes on a development in the degree in which the organs and functions of the individual are so correlated and united as to respond promptly and effectually to the answering changes in the environment. Contemplating now the correspondences in their totality, it is found that the generalization on which it was proposed to base a synthetic Psychology is established, that manifestations of intelligence are found to consist in the establishment of correspondences between relations in the organism and relations in the environment, and the preliminary assumption that life and mind are fundamentally identical is proved.

Nevertheless, though these two kinds of life are primordially the same, they are in their general aspects widely unlike, and we must inquire whence the differences arise. Instinct, Memory, Reason, Feeling, and Will, have specific differences; a science of Psychology which is based on the theory of development must determine whence these

[1] "Psychology," second edition (1870), volume i., section 53. Swedenborg's "Law of Correspondences" is not without analogy to Mr. Spencer's original generalization.

arise, and, if mind is merely a higher manifestation of life, they must be interpretable as life was interpreted.

Intelligence in general is differenced from life in general by the fact that the order of changes of which it consists is successive. The science of intelligence having thus for its subject-matter a continued series of changes, it is the business of Psychology to determine the law of their succession. Bringing up the "law of correspondences" left in the rear, it is found that one mental state tends to follow another with a strength proportionate to the intimate union between the external things they represent. Here is a "law of association" of Hegelian depth, cutting down to the adamantine pillars of the universe, and compared with which the so-called laws of association are mere empiricism. The law is also of Hegelian content—rivaling that cocoon *das Werden*, and out of it shall be woven all the phenomena of unfolding intelligence. Reflex action we have already seen Mr. Bain incorporate in Psychology; Mr. Spencer shows how it necessarily arises out of developing life. Instinct, too, Mr. Bain prefixes to his analysis of ideas; Mr. Spencer evolves it out of reflex action. With the increasing complexity of experience Memory arises, and Mill's "insoluble problem" is solved. The chapter on Reason is, perhaps, the finest synthetic exposition in the literature of Psychology. Reason, like Memory, is shown to be developed by an insensible transition out of instinct; and Locke is reconciled with Kant by the intervention of that theory of the secular transmission of mental acquisitions which has become so familiar that it is now difficult to appreciate its daring originality. Feeling, like Reason, arises out of instinct; and emotions of the greatest complexity, power, and abstractness, are formed out of the simple aggregation of large groups of emotional states into still larger groups through endless past ages. Thus out of the feeble beginnings of life have been woven all the manifestations of mind, up to the highest abstractions of a Hegel and the infinitely complex and voluminous emotions of a Beethoven. Well may a French writer say: "Si on la rapproche par la pensée des tentatives de Locke et de Condillac sur ce sujet, la genèse sensualiste paraîtra d'une simplicité enfantine." [1]

Hitherto the psychologist, proceeding objectively, has made no use of consciousness; and it is now necessary, in order to justify the findings of the synthetic method, to examine consciousness in the only possible way—by analysis. Setting out with the highest conceivable display of mind, compound quantitative reasoning, he tracks all the mental phenomena down to that which is *only* a change in consciousness, the establishment of the relation of sequence, and proves that the genesis of intelligence has advanced in the same way as was shown in the synthesis—by the establishment and consolidation of relations of increasing complexity. Thus throughout all the phenomena of

[1] Ribot, "La Psychologie Anglaise," p. 215.

mind there exists a unity of composition; and the doctrines of innate ideas, intuitions by gift of God, supernatural revelations, mysticism of all kinds, have the ground cut from under them.

The very great extension of plan which Mr. Spencer's work received between 1855 and 1870–'72 was due solely to the creation of his own philosophy of evolution. That in its turn had its initiative in the theory of the correlation of forces advanced by Grove in 1842. As the new philosophy conceived all existence to result from evolution through differentiation and integration, it was incumbent on Mr. Spencer to show that mental phenomena, or at least the physical correlatives of them, can be interpreted in terms of the redistribution of matter and motion, and explained by a series of deductions from the persistence of force. This is the task of a Physical Synthesis, which shows the structure and functions of the nervous system to have resulted from intercourse between the organism and its environment. And thus is laid the coping-stone of a treatise which has definitively constituted Psychology a science.

With the definitive constitution of the science our inquiry, which began with the differentiation of its subject-matter, comes to an end. We have seen mind slowly emancipating itself from the barbaric Cosmos, and raised into an independent object of speculation. Once "differentiated" it begins itself to unfold, and at the same time to gather round it the at first alien facts of sensation, appetite, and bodily feeling generally. These are increasingly matter of inquiry, and theories respecting them take the hue and shape of the sciences which relate to the material world. The science of motion evolves, and the idea of orderly sequence enters into Psychology. Natural Philosophy rises from motion to force, and Psychology passes from conjunction to causation. Chemistry tears aside a corner of Nature's veil, and a shaft is sunk in a mysterious field of mind. The sciences of organic nature receive a forward impulse, and mind and life are joined in inextricable union. A philosophy of the universe, incorporating all the sciences, is created, and Psychology, while attaining increased independence as regards the adjacent sciences, is merged in that deductive science of the Knowable which has more widely divorced, and yet more intimately united, the laws of matter and of mind.—*Westminster Review.*

DISTANCES OF THE STARS.

By CAMILLE FLAMMARION.

TRANSLATED FROM THE FRENCH OF LA NATURE, BY J. FITZGERALD, A. M.

SINCE the beginning of this century, our idea of the universe has undergone a complete metamorphosis, though but few persons appear to recognize this fact. Less than a century ago, the *savants* who admitted the earth's motion (some still rejected it) pictured to themselves the system of the universe as being bounded by the frontier of Saturn's orbit, at a distance from the central sun equal to 109,000 times the diameter of the earth, or about 860,000,000 miles. The stars were *fixed*, spherically distributed, at a distance but a little greater than that of Saturn. Beyond this limit a vacant space was supposed to surround the universe. The discovery of Uranus, in 1785, did away at once with this belt, consisting of Saturn's orbit, and the frontier of solar domination was pushed out to a distance of 1,900,000,000 miles from the centre of the system, that is to say, beyond the space which was vaguely supposed to be occupied by the stars. The discovery of Neptune, in 1846, again removed these limits to a distance that would have appalled our fathers; the orbit described by this planet being 2,862,000,000 miles from the sun.

But the attractive force of the sun extends farther still. Beyond the orbit of Uranus, beyond the dark route slowly traversed by Neptune, the frigid wastes of space are traveled over by the comets in their erratic courses. Of these, some, being controlled by the sun, do not leap from system to system, but move in closed curves, though at distances far greater than those of Uranus and Neptune. Thus Halley's comet recedes to a distance of over 3,200,000,000 miles from the sun; the comet of 1811, 36,000,000,000; and that of 1680, 75,000,000,000. The period of the last-named comet is 8,800 years.

Still these figures can scarcely be compared to those which represent the distances of the stars. What means have we of measuring these distances? Here the diameter of the earth will not serve as the base of the triangle, as when we measure the moon's distance; nor can we, as in the case of the sun, get any assistance from another planet. However, fortunately for us, the arrangement of our system affords us a means of measuring these distant perspectives; and this, while demonstrating over again the earth's motion round the sun, turns that motion to account for the solution of the greatest of astronomical problems.

In revolving round the sun, at the distance of 92,000,000 miles, the earth annually describes an ellipse of about 500,000,000 miles. The diameter of this orbit is 184,000,000 miles. As the earth's revolution round the sun is performed in a year, the earth, at any given instant, will be opposite to the point where it stood six months before, as also to the point where it will stand six months later. Here is a line of sufficient length to serve as base of a triangle the apex of which shall be a star.

The process, then, for measuring the distance of a star from the earth consists in minutely observing this star at an interval of six months, or better, for a whole year, noting whether it remains fixed, or whether it undergoes some little appreciable displacement of perspective, owing to the annual displacement of the earth around the sun. If it remains fixed, this is because it is at an infinite distance from us—at the horizon of the heavens, so to speak—and our base-line of 184,000,000 miles is as nothing in comparison with this remoteness. But if it is displaced, then we know that it annually describes a small ellipse, corresponding to the annual revolution of the earth. Every one has remarked, while traveling by rail, how the trees and other objects near at hand move in a direction contrary to our own, their speed being greater in proportion to their nearness; whereas distant objects on the horizon remain fixed. This same effect is produced in space, in consequence of our annual motion round the sun. But though we move incomparably swifter than an express-train, our rate being 1,632,000 miles per day, and 68,000 per hour, the stars are so distant that they scarcely budge. Our 184,000,000 miles of displacement are almost nothing as concerns even the nearest of them. The inhabitants of Jupiter, Saturn, Uranus, or Neptune, with their orbits five, nine, nineteen, and thirty times as large as ours, could determine the distance of a far greater number of stars than we.

This mode of measuring the distance of the stars by the perspective effect produced by the earth's annual displacement was anticipated by the astronomers of the eighteenth century, and in particular by Bradley, who, while attempting to measure the distances of the stars by comparing together observations made at an interval of six months, discovered—something else. Instead of finding the distance of the stars on which his observations were directed, he discovered a very important optical phenomenon, viz., the *aberration of light*, the effect produced by the motion of light and the motion of the earth combined. Similarly, William Herschel, while seeking the parallaxes of the stars by comparing bright stars with their nearest neighbors, discovered the systems of double stars. So, too, Fraunhofer, while seeking the limits of the colors in the solar spectrum, discovered the absorption rays, the study of which has given rise to Spectrum Analysis. The history of the sciences shows that frequently discoveries have been made in the course of investigations which had but little to do with them directly. Columbus discovered the New World while aiming to reach the eastern coast of Asia by sailing to the west. He would never have discovered it, would never have sought for it, had he known the true distance between Portugal and Kamtchatka.

It was not till 1840 that the distance of any of the stars was ascertained. This discovery is, therefore, of recent date, and we are only now beginning to form an approximate idea of the real distances which separate us from the stars. The parallax of the star 61 in the Swan, which was the first to be determined, was ascertained by Bessel, and was the result of observations made at Königsberg from 1837 to 1840. In 1812, Arago and Mathieu had made observations on this star, but without reaching any certain results. The parallax of Alpha in the Lyre was found by Struve, in the course of observations made at Dorpat between 1835 and 1838; but it was not published till after the year 1840. The same is to be said of Alpha in Centaur, observed in 1832 and in 1839 on the Cape of Good Hope by Henderson and Maclear; this is the nearest to us of all the stars.

There are two ways of determining these parallaxes. The first is, to compare together the positions observed at intervals of six months; the other, to discover an apparent motion in a star (as compared with a motionless star situated at a far greater distance than that which is studied): this apparent motion being due to the perspective produced by the annual revolution of the earth in its orbit. This is the method mostly employed now. Galileo, in his "Dialogues;" Gregory, in the "Proceedings of the Royal Society" (1675); Huyghens, in his "Cosmotheoros," published in 1695; Condorcet, in his "*Éloge* of Roemer," in 1773; and William Herschel, in 1781, have described both methods. Hooke, Flamstead, Cassini, Bradley, Robert Long, Herschel, Piazzi, and Brinkley, strove, from 1674 to 1820, to determine the small quantity of the apparent movement of the brightest stars, which used to be regarded as the nearest; but their efforts were fruitless, owing to the inconsiderable amount of this motion. There was need of instruments of the utmost precision, a rigid spirit of observation, and an indomitable patience, in order to get at trustworthy results.

Since 1840 the attention of astronomers has been oftentimes directed to this investigation, and thousands of calculations have been made. With great difficulty astronomers have succeeded in determining the parallaxes of *a few* stars. But the inevitable errors of observation often involve the results in obscurity. Let the reader only bear in mind that there is not *one* star that is sufficiently near to give us a parallax of *one second!* A second is the dimension to which would be reduced a circle one metre (3 ft. 3.37 in.) in diameter carried away to a distance of 206 kilometres (127.72 miles) from the eye. This appears to be less than nothing: it is equal to the thickness of a hair stretched at the distance from the eye of 20 metres (74 feet). The apparent annual movement of a star, whose distance can be known, is performed altogether within this infinitesimal space. For an observer on the star that is nearest to us, this hair would conceal the whole space between the earth and the sun.

As no star offers a parallax of one second, it follows that the nearest of the stars is distant from earth no less than 206,265 times 92,000,000 miles. The space which surrounds the planetary system is void of stars to that distance at least.

The star which is nearest to us, Alpha of Centaur, has a parallax of 0.″91. Its distance from earth is 226,400 times the radius of the earth's orbit, or 21,000,000,000,000 miles. This is our *neighbor* star, and its distance is probably the minimum distance between star and star—21,000,000,000,000 miles. Each of these stars shines with its own light—is a sun like our own.

The second star, in the order of distances, is 61 Cygni. Its parallax is 0.″51, and its remoteness 37,000,000,000,000 miles.

Of the thousands of stars which have been studied, we know the distances of only twenty. Among these we may signalize Sirius, a sun 2,688 times larger than our own, surrounded by a system of heavenly bodies, several of which are already known, and distant from us 82,000,000,000,000 miles; the Polar Star, which is a double star, distant 292,000,000,000,000 miles; and Capella, distant 425,000,000,000,000—a space which is traversed by light in seventy-one years and eight months; so that the luminous ray which reaches us from this fine star in 1874 must have started out in 1803! Capella might have been extinguished in 1804, but we should see it still. It might go out to-day, and yet the inhabitants of the earth would continue to admire it in their heavens until 1946. Conversely, if there existed, on the planets gravitating round Capella, minds whose transcendent vision could thence descry our little earth, lost as it is amid the sun's rays, they would now see the earth of the year 1803, and would be seventy-one years eight months behindhand in its history. These are the stars that are nearest to us. The others are incomparably more remote.

There are stars whose light cannot reach us in less than 100, 1,000, or 10,000 years, though light travels at the rate of 185,000 miles per second!

To traverse the sidereal world of which we form part (the Milky-Way), light takes 15,000 years.

To reach us from certain of the nebulæ, it must travel for 300 times that period, or 5,000,000 years.

Let the imagination, that is not appalled by these immensities, strive to conceive of them. If it does not experience the "vertigo of the infinite," let it calmly contemplate these abysses, and realize the position of the earth and of man in presence of them. Thus will it gain some conception of the discoveries made by sidereal astronomy.

Such are the dimensions actually measured in the general constitution of the universe. As yet we are only at the vestibule of the edifice, on the edge of the abyss of infinitude: and we shall never penetrate very far beyond.

FEMALE SUFFRAGE.

By Professor GOLDWIN SMITH.

MR. FORSYTH'S bill for removing the electoral disabilities of women, the second reading of which is at hand, has received less attention than the subject deserves. The residuum was enfranchised for the sake of its vote by the leaders of a party which for a series of years had been denouncing any extension of the suffrage, even to the most intelligent artisans, on the ground that it would place political power in unfit hands. An analogous stroke of strategy, it seems, is now meditated by the same tacticians in the case of female suffrage, the motion in favor of which is brought forward by one of their supporters, and has already received the adhesion of their chief. The very foundations of society are touched when party tampers with the relations of the sexes.

In England the proposal at present is to give the suffrage only to unmarried women being householders. But the drawing of this hard-and-fast line is at the outset contested by the champions of women's rights; and it seems impossible that the distinction should be maintained. The lodger-franchise is evidently the vanishing-point of the feudal connection between political privilege and the possession of houses or land. The suffrage will become personal in England, as it has elsewhere. If a property qualification remains, it will be one embracing all kinds of property: money settled on a married woman for her separate use, as well as the house or lodgings occupied by a widow or a spinster. In the counties already, married women have qualifications in the form of land settled to their separate use; and the notion that a spinster in lodgings is specially entitled to the suffrage, as the head of a household, is one of those pieces of metaphysics in which the politicians who affect to scorn any thing metaphysical are apt themselves unwarily to indulge. If the present motion is carried, the votes of the female householders, with that system of election pledges which is now enabling minorities, and even small minorities, to control national legislation, will form the crow-bar by which the next barrier will be speedily forced.

Marriage itself, as it raises the position of a woman in the eyes of all but the very radical section of the Woman's Right party, could hardly be treated as politically penal. And yet an act conferring the suffrage on married women would probably be the most momentous step that could be taken by any legislature, since it would declare the family not to be a political unit, and for the first time authorize a wife, and make it in certain cases her duty as a citizen, to act publicly in opposition to her husband. Those at least who hold the family to be worth as much as the state will think twice before they concur in such a change.

With the right of electing must ultimately go the right of being elected. The contempt with which the candidature of Mrs. Victoria Woodhull for the presidency was received by some of the advocates of female suffrage in America only showed that they had not considered the consequences of their own principles. Surely she who gives the mandate is competent herself to carry it. Under the parliamentary system, whatever the forms and phrases may be, the constituencies are the supreme arbiters of the national policy, and decide not only who shall be the legislators, but what shall be the course of legislation. They have long virtually appointed the ministers, and now they appoint them actually. Twice the Government has been changed by a *plébiscite*, and on the second occasion the budget was submitted to the constituencies as directly as ever it was to the House of Commons. There may be some repugnance, natural or traditional, to be overcome in admitting women to seats in Parliament; but there is also some repugnance to be overcome in throwing them into the turmoil of contested elections, in which, as soon as female suffrage is carried, some ladies will unquestionably claim their part.

There are members of Parliament who shrink from the step which they are now urged to take, but who fancy that they have no choice left them because the municipal franchise has already been conceded. The municipal franchise was no doubt intended to be the thin end of the wedge. Nevertheless there is a wide step between this and the national franchise; between allowing female influence to prevail in the disposition of school-rates, or other local rates, and allowing it to prevail in the supreme government of the country. To see that it is so, we have only to imagine the foreign policy of England determined by the women, while that of other countries is determined by the men; and this in the age of Bismarck.

The writer of this paper himself once signed a petition for female household suffrage got up by Mr. Mill. He has always been for enlarging the number of active citizens as much as possible, and widening the basis of government, in accordance with the maxim, which seems to him the sum of political philosophy, "That is the best form of government which doth most actuate and dispose all parts and members of the commonwealth to the common good." He had not, when he signed the petition, seen the public life of women in the United States. But he was led to reconsider what he had done, and prevented from going further, by finding that the movement was received with mistrust by some of the best and most sensible women of his acquaintance, who feared that their most valuable privileges, and the deepest sources of their happiness, were being jeopardized to gratify the political aspirations of a few of their sex. For the authority of Mr. Mill, in all cases where his judgment was unclouded, the writer felt and still feels great respect. But, since that time, Mr. Mill's autobiography has appeared, and has revealed the history of his extraordinary and almost portentous education, the singular circumstances of his marriage, his hallucination (for it surely can be called nothing less) as to the unparalleled genius of his wife, and peculiarities of character and temperament such as could not fail to prevent him from fully appreciating the power of influences which, whatever our philosophy may say, reign and will continue to reign supreme over questions of this kind. To him marriage was a union of two philosophers in the pursuit of truth; and, in his work on the position and destiny of women, not only does he scarcely think of children, but sex and its influences seem hardly to be present to his mind. Of the distinctive excellence and beauty of the female character it does not appear that he had formed any idea, though he dilates on the special qualities of the female mind.

Mr. Mill has allowed us to see that his opinions as to the political position of women were formed early in his life, probably before he had studied history rationally, perhaps before the rational study of history had even come into existence. The consequence, with all deference to his great name be it said, is that his historical presentment of the case is fundamentally unsound. He and his disciples represent the lot of the woman as having always been determined by the will of the man, who, according to them, has willed that she should be the slave, and that he should be her master and her tyrant. "Society, both in this" (the case of marriage) "and other cases, has preferred to attain its object by foul rather than by fair means; but this is the only case in which it has substantially persisted in them even to the present day." This is Mr. Mill's fundamental assumption; and from it, as every rational student of history is now aware, conclusions utterly erroneous as well as injurious to humanity must flow. The lot of the woman has not been determined by the will of the man, at least in any considerable degree. The lot both of the man and the woman has been determined from age to age by circumstances over which the will of neither of them had much control, and which neither could be blamed for accepting or failing to reverse. Mr. Mill, and those who with him assume that the man has always willed that he should himself enjoy political rights, and that the woman should be his slave, forget that it is only in a few countries that man does enjoy political rights; and that, even in those few countries, freedom is the birth almost of yesterday. It may probably be said that the number of men who have really and freely exercised the suffrage up to the present time is not much greater than the number of those who have in different ages, and in various ways, laid down their lives or made personal sacrifices of other kinds in bringing the suffrage into existence.

In the early stages of civilization the family was socially and legally as well as politically a unit. Its head represented the whole household before the tribe, the state, and all persons and bodies without; while within he exercised absolute power over all the members, male as well as female, over his sons as well as over his wife and daughters. On the death of the head of a family his eldest son stepped into his place, and became the representative and protector of the whole household, including the widow of the deceased chief. This system, long retained in conservative Rome, was there the source of the national respect for authority, and, by an expansion of feeling from the family to the community, of the patriotism which produced and sustained Roman greatness. But its traces lingered far down in history. It was not male tyranny that authorized a Tudor queen to send members of the royal household to the Tower by her personal authority as the mistress of the family, without regard to the common law against arbitrary imprisonment. Such a constitution was essential to the existence of the family in primitive times; without it, the germs of nations and of humanity would have perished. To suppose that it was devised by the male sex for the gratification of their own tyrannical propensities would be most absurd. It was at least as much a necessity to the primitive woman as it was to the primitive man. It is still a necessity to woman in the countries where the primitive type of society remains. What would be the fate of a female Bedouin, if she were suddenly invested with woman's rights and emancipated from the protection of her husband?

That the present relation of women to their husbands literally has its origin in slavery, and is a hideous relic of that system, is a theory which Mr. Mill sets forth in language such as, if it could sink into the hearts of those to whom it is addressed, would turn all affection to bitterness, and divide every household against itself. Yet this theory is without historical foundation. It seems, indeed, like a figure of invective heedlessly converted into history. Even in the most primitive times, and those in which the subjection of the women was most complete, the wife was clearly distinguished from the slave. The lot of Sarah is different from that of Hagar; the authority of Hector over Andromache is absolute, yet no one can confound her position with that of her handmaidens. The Roman matron who sent her slave to be crucified, the Southern matron who was the fierce supporter of slavery, were not themselves slaves. Whatever may now be obsolete in the relations of husband and wife is not a relic of slavery, but of primitive marriage, and may be regarded as at worst an arrangement once indispensable which has survived its hour. Where real slavery has existed, it has extended to both sexes, and it has ceased for both at the same time. Even the Oriental seclusion of women, perhaps the worst condition in which the sex has ever been, has its root, not in the slave-owning propensity so much as in jealousy, a passion which, though extravagant and detestable in its excessive manifestation, is not without an element of affection. The most beautiful building in the East is that in which Shah Jehan rests by the side of Nourmahal.

If the calm and philosophic nature of Mr. Mill is ever betrayed into violence, it is in his denunciations of the present institution of marriage. He depicts it as a despotism full of mutual degradation, and fruitful of no virtues or affections except the debased virtues and the miserable affections of the master and the slave. The grossest and most degrading terms of Oriental slavery are used to designate the relations of husband and wife throughout the whole book. A husband who desires his wife's love is merely seeking "to have, in the woman most nearly connected with him, not a forced slave, but a willing one—not a slave merely, but a favorite." Husbands have, therefore "put every thing in practice to enslave the minds of their wives." If a wife is intensely attached to her husband, "exactly as much may be said of domestic slavery. . . . It is part of the irony of life that the strongest feelings of devoted gratitude of which human nature seems to be susceptible are called forth in human beings toward those who, having the power entirely to crush their earthly existence, voluntarily refrain from using their power." Even children are only links in the chain of bondage. By the affections of women "are meant the only ones they are allowed to have—those to the men with whom they are connected, or to the children who constitute an additional and indefeasible tie between them and a man." The Jesuit is an object of sympathy because he is the enemy of the domestic tyrant, and it is assumed that the husband can have no motive but the love of undivided tyranny for objecting to being superseded by an intriguing interloper in his wife's affections. As though a wife would regard with complacency, say a female spiritualist, installed beside her hearth! It is impossible to doubt that Mr. Mill's views, in writing such passages, were colored by the incidents of his life. But it is by circulating his book and propagating his notions that the petitions in favor of female suffrage have been obtained.

The anomalies in the property law affecting married women, to which remedial legislation has recently been directed, are like whatever is obsolete in the relations between the sexes generally, not deliberate iniquities, but survivals. They are relics of feudalism, or of still more primitive institutions incorporated by feudalism; and, while the system to which they belonged existed, they were indispensable parts of it, and must have been so regarded by both sexes alike. Any one who is tolerably well informed ought to be ashamed to represent them as the contrivances of male injustice. It is not on one sex only that the relics of feudalism have borne hard.

The exclusion of women from professions is cited as another proof of constant and immemorial injustice. But what woman asked or wished to be admitted to a profession fifty or even five-and-twenty years ago? What woman till quite recently would have been ready to renounce marriage and maternity in order that she might devote herself to law, medicine, or commercial pursuits? The fact is, the demand is connected with an abnormal and possibly transient state of things. The expensiveness of living, in a country where the fashion is set by millionaires, combined with the overcrowded condition of the very callings to which women are demanding admission, has put extraordinary difficulties in the way of marriage. Many women are thus left without an object in life, and they naturally try to open for themselves some new career. The utmost sympathy is due to them, and every facility ought in justice to be afforded them; though unhappily the addition of fresh competitors for subsistence, to a crowd in which literally famine has already been at work, will be as far as possible from removing the real root of the evil; to say nothing of the risk which a woman must run in committing herself irrevocably to a precarious calling and closing against herself the gate of domestic life. But the demand, as has been already said, is of yesterday, and probably in its serious form is as yet confined to the countries in which the special impediments to early marriages exist. In the United States it is not easy to distinguish the serious demand from a passion for emulating the male sex which has undoubtedly taken possession of some of the women there, as it took possession of women under the Roman Empire, who began to play the gladiator when other excitements were exhausted. With regard to the profession of law, indeed, so far as it is concerned with the administration of justice, there is, and, while human emotions retain their force, always will be, a reason, independent of the question of demand, for excluding women, at least for excluding one of the two sexes. The influence of a pretty advocate appealing to a jury, perhaps in behalf of a client of her own sex, would not have seemed to Mr. Mill at all dangerous to the integrity of public justice; but most people, and especially those who have seen any thing of sentimental causes in the United States, will probably be of a different opinion.

What has been said as to the professions is equally true of the universities, which, in fact, were schools of the professions. A few years ago, what English girl would have consented to leave her home and mingle with male students? What English girl would have thought it possible that she could go through the whole of the medical course with male companions of her studies? Even now, what is the amount of settled belief in the right, as it is termed, of "coeducation?" What would be said to a young man if he presented himself in the name of that right at the door of Vassar, or any female college? Without arraigning the past, those whose duty it is may consider, with the deliberation which they deserve, the two distinct questions, whether it is desirable that the education of both sexes shall be the same, and whether it is desirable that the young men and the young women of the wealthier classes shall be educated together in the same universities. Beneath the first probably lies the still deeper question whether it is good for humanity that woman, who has hitherto been the helpmate and the complement, should become, as the leaders in the woman's right movement in the United States evidently desire, the rival and competitor of man. Both she cannot be; and it is by no means clear that, in deciding which she shall be, the aspirations of the leaders of this movement coincide with the interests of the sex.[1]

If the education of women has hitherto been defective, so has that of men. We are now going to do our best to improve both. Surely no accomplishment in the acquisition of which woman has been condemned to spend her time could well be less useful than that of writ-

[1] The question of female education is not here discussed. But the arbiters of that question will do well to bear in mind that the happiness of most women materially depends on their having healthy children; and that children are not likely to be healthy if the brains of both parents are severely tasked.

ing Greek and Latin verses. That the comparative absence of works of creative genius among women is due entirely to the social tyranny which has excluded, or is supposed to have excluded, them from literary and scientific careers, cannot be said to be self-evident. The case of music, often cited, seems to suggest that there is another cause, and that the career of intellectual ambition is in most cases not likely to be happier than that of domestic affection, though this is no reason why the experiment should not be fairly tried. Perhaps the intellectual disabilities under which women have labored, even in the past, have been somewhat exaggerated. If Shelley was a child to Mrs. Mill, as Mr. Mill says, no "social disabilities" hindered Mrs. Mill from publishing poems which would have eclipsed Shelley. The writer once heard an American lecturer of great eminence confidently ascribe the licentiousness of English fiction in the early part of the last century to the exclusion of women from literary life. The lecturer forgot that the most popular novelist of that period, and certainly not the least licentious, was Mrs. Aphra Behn. And this lady's name suggests the remark that as the relations of the sexes have been the most intimate conceivable, the action of character has been reciprocal, and the level of moral ideas and sentiments for both pretty much the same.

Mr. Mill, seeing that the man is the stronger, seems to assume that the relations between man and woman must always have been regulated simply by the law of the strongest. But strength is not tyranny. The protector must always be stronger than the person under his protection. A mother is overwhelmingly superior in strength to her infant child, and the child is completely at her merey. The very highest conception that humanity has ever formed, whether it be founded in reality or not, is that of power losing itself in affection. This may be said without lapsing into what has been called the religion of inhumanity. St. Paul (who on any hypothesis is an authoritative expositor of the morality which became that of Christendom) preaches fraternity plainly and even passionately enough. He affirms with the utmost breadth the essential equality of the sexes, and their necessary relations to each other as the two halves of humanity. Yet he no less distinctly ratifies the unity of the family, the authority of its head, and the female need of personal government; a need which, when it is natural, has nothing in it more degrading than the need of protection.

The "Revolt of Woman" is the name given to the movement by a female writer in America, who, by-the-way, claims, in virtue of "superior complexity of organization," not only political equality, but absolute supremacy over man. But, in this revolt, to what do the insurgents appeal? To their own strength, or to the justice and affection of man?

The main factors of the relation between the sexes have hitherto been, and probably still are, natural affection—the man's need of a helpmate, the woman's need of a protector and provider, especially when she becomes a mother, and the common interest of parents in their children. One of these factors must be withdrawn, or greatly reduced in importance, to warrant us in concluding that a fundamental change in the relation is about to take place. Mr. Mill hardly notices any one of the four, and he treats the natural relation which arises from them as a purely artificial structure, like a paper constitution or an act of Parliament, which legislatures can modify or abolish at their pleasure.

It has no doubt been far from a satisfactory world to either sex; but unless we attach a factitious value to public life and to the exercise of public professions, it will be very difficult to prove that it has been more unsatisfactory for one sex than the other. If the woman has had her sorrows at home, the man has had his wars and his rough struggles with Nature abroad, and with the sweat of his brow he has reclaimed the earth, and made it a habitation for his partner as well as for himself. If the woman has had her disabilities, she has also had her privileges. War has spared her; for, if in primitive times she was made a slave, this was better, in the days before sentiment at least, than being massacred. And her privileges have been connected with her disabilities. If she had made war by her vote, she could not have claimed special respect as a neutral, nor will she be able to claim special respect as a neutral if she makes war by her vote hereafter.

In the United States the privileges of women may be said to extend to impunity, not only for ordinary outrage, but for murder. A poisoner, whose guilt has been proved by overwhelming evidence, is let off because she is a woman; there is a sentimental scene between her and her advocate in court, and afterward she appears as a public lecturer. The whiskey crusade shows that women are practically above the law. Rioting, and injury to the property of tradesmen, when committed by the privileged sex, are hailed as a new and beneficent agency in public life; and because the German population, being less sentimental, asserts the principles of legality and decency, the women are said to have suffered martyrdom. So far from the American family being the despotism which Mr. Mill describes, the want of domestic authority lies at the root of all that is worst in the politics of the United States. If the women ask for the suffrage, say some American publicists, they must have it; and in the same way every thing that a child cries for is apt to be given it, without reflection as to the consequences of the indulgence.

There is therefore no reason for setting the sexes by the ears, or giving to any change which it may be just and expedient to make the aspect of a revolt. We may discuss on its own merits the question whether female suffrage would be a good thing for the whole community. The interest of the whole community must be the test. As to natural rights, they must be sought by those who desire them, not in communities, but in the primeval woods, where the available rights of women will be small.

The question whether female suffrage on an extended scale is good for the whole community is probably identical, practically speaking, with the question whether it is good for us to have free institutions or not. Absolute monarchy is founded on personal loyalty. Free institutions are founded on the love of liberty, or, to speak more properly, on the preference of legal to personal government. But the love of liberty and the desire of being governed by law alone appear to be characteristically male. The female need of protection, of which, so long as women remain physically weak, and so long as they are mothers, it will be impossible to get rid, is apparently accompanied by a preference for personal government, which finds its proper satisfaction in the family, but which gives an almost uniform bias to the political sentiments of women. The account commonly accepted, of the reactionary tendency which all admit to be generally characteristic of the sex, is, that they are priest-ridden. No doubt many of them are priest-ridden, and female suffrage would give a vast increase of power to the clergy. But the cause is probably deeper and more permanent, being, in fact, the sentiment inherent in the female temperament, which again is formed by the normal functions and circumstances of the sex. And, if this is the case, to give women the franchise is simply to give them the power of putting an end, actually and virtually, to all franchises together. It may not be easy to say beforehand exactly what course the demolition of free institutions by female suffrage would take. In the United States probably some woman's favorite would be elected President, and reëlected till his power became personal, and perhaps dynastic. But there can be little doubt that in all cases, if power were put into the hands of women, free government, and with it liberty of opinion, would fall.

In France, it is morally certain that at the present moment, if votes were given to the women, the first result would be the restoration to power of the Bourbons, with their reactionary priesthood, and the destruction of all that has been gained by the national agonies of the last century. The next result would be a religious crusade against German Protestantism and Italian freedom.

But would the men submit? Would they, in compliance with the edict of the women, and in obedience to a woman's government, haul down the tricolor, hoist the white flag, bow their necks to the yoke of reaction, and march against the victors of Sedan in a cause which they detest? This question points to another serious consideration. It is true that law is much stronger now than it was in primitive or feudal times, and a woman is more under its protection and less under the private protection of her husband and her kinsmen. But law, after all, though the fact may be rough and unwelcome, rests at bottom on the force of the community, and the force of the community is male. No woman can imagine that her sex can execute, or in case of rebellion reassert, the law; for that they must look entirely to the men. The men would be conscious of this, and, if any law were made exclusively in the interest of the women, and in contradiction to the male sense of justice, they would refuse to carry it into effect. In the United States there have been intimations, on the part of the women, of a desire to make a very lavish use of capital punishment, untrammeled by the technical rules of evidence, for offenses or supposed offenses against the sex. The men would, of course, refuse execution; law would be set at defiance, and government would be overturned. But the bad effects of the public consciousness that executive force—the rude but indispensable basis of law—had been partly removed, and that the law was being made by those who had not the power to carry it into effect, would not be limited to manifest instances of the influence of sex in legislation. In cases where, as in Jamaica, an elective government has rested on two races, equal, legally speaking, in political power, but of which one was evidently inferior in real force to the other, reverence for law has been weak, and the result has been disastrous. There can be little doubt that, as soon as the Federal bayonets are removed, there will be another case of the same kind in the Southern States; laws made by negro majorities will be set at defiance by the stronger race. To personal despotism or class domination civilization can put an end, but it cannot eliminate force.

It is very likely that in England the women, to reform drunken husbands, would vote for extreme prohibitory measures against liquor; but the difficulty of carrying such legislation into effect, great as it is already, could hardly fail to be much increased by the feeling that it was the act of the women, and the consequence would probably be contempt, and perhaps open defiance, of the law. Female legislation with regard to education, in the interest of clerical ascendency, would be apt to be attended by the same effects.

Elective government, with the liberty of opinion and the power of progress which are its concomitants, has been brought into existence by the most terrible throes of humanity. When perfected and firmly established, it will, as we hope, and have good grounds for believing, give to reason and justice an ascendency which they have never had before in human affairs, and increase the happiness of all by making private interest subordinate to the public good. But its condition, if we look at the world as a whole, is still exceedingly precarious. All the powers of class interest, of sybaritism, of superstition, are arrayed against it, and have vast forces at their command, including the great standing armies of Europe, while they find accomplices in the lassitude, the alarm, the discouragement caused by the revolutionary storms which, unhappily, are almost inevitable attendants upon the birth of a new order of things. Its existence having been so far a struggle, and an assertion at the sword's point, of principles, just in themselves, but needing qualification to make them available as the foundations of a polity, it is full of defects, to remedy which, so as to make it the deliberate expression of public reason, clear of sectional interest and passion, is now the great aim of political thought and effort. Those to whose hands it is committed at this crisis are trustees for posterity of a heritage bought by ages of effort and torrents of blood; and they are bound to allow neither their own ambition nor that of any one else, if they can help it, to imperil the safety of their trust. That women would be likely to vote for one set of aspirants to political office rather than for the opposite set, would be a very bad reason for withholding from them the suffrage even for a day; but, that they would probably overturn the institutions on which the hopes of the world rest, is as good a reason as there can be for withholding any thing from anybody. When free institutions are firmly established in Europe, the question of female suffrage may perhaps be raised with less peril, so far as political interests are concerned; but, to take a female vote on their fate at present, would be as suicidal as it would have been to take a female vote on the issues between Charles I. and the Parliament in the middle of the Civil War.

So far as elective government has succeeded, women in general have fully reaped the benefit of the improvements, moral and material, which it has produced. They are mistaken if they imagine that they fared better under the form of government which, in France and elsewhere, if they had the power, their sentiment would lead them to restore. They were not exempt from the misery and starvation brought into every home by the ambitious wars and the general misrule of the monarchies or even from the cruelty of their criminal laws. Down to the last days of the monarchy in France women as well as men were broken alive upon the wheel for theft.

It is needless to say that any discussion of the relative excellence, intellectual or moral, of the two moieties of humanity would be equally barren and irrelevant. The only question is as to the proper spheres of the man and woman; and assuredly, by unsexing women, we should do no homage to their sex.

It is alleged that female influence would mitigate the violence of party politics. But what ground have we, in reason or experience, for believing that women, if introduced into the political arena, would be less violent than men? Hitherto they have been free from political vices, because they have generally taken no part in politics, just as home has been an asylum from political rancor, because political division has not been introduced between man and wife. But the chances are, that, being more excitable, and having, with more warmth and generosity of temperament, less power of self-control, women would, when once engaged in party struggles, be not less but more violent than men. All our experience, in fact, points this way. In the Reign of Terror, and in the revolt of the Commune, the women notoriously rivaled the men in fury and atrocity. The same was the case in the late American Civil War. What has been the effect of public life on the character of the women who have thrown themselves into it in the United States can be doubted by no human being; and our experience of female agitations in this country seems to tell pretty much the same tale. That party politics require mitigation, and perhaps something more, may be readily admitted; but we are not likely to make the caldron boil less fiercely by flinging into it female character and home.

That home would escape disturbance it is surely difficult to believe. We are told that a difference of religion between man and wife does not produce unhappiness. The fact may be doubted when the difference is strong. But religion is an affair of the other world; and it does not, at all events it need not, bring people into direct, much less into public collision in this world. A man and his wife, taking opposite sides in politics, would be brought into direct and public collision, especially if they happened to be active politicians, about a subject of the most exciting kind. Would the harmony of most households bear the strain? Would not a husband who cared for his own happiness be apt to say that if his wife wanted it she might have the vote, but that there should be only one vote between them?

Men are not good house-keepers, and there need not be any thing disparaging in saying that women, as a rule, are not likely to be good politicians. Most of them, after all, will be married, and their sphere will be one in which they do not directly feel the effects of good or bad government, which are directly felt by the man who goes forth to labor, and the practical sense of which, more than any thing else, forms the political wisdom, such as it is, of the great mass of mankind. Nor would there be any thing, generally speaking, to balance the judgment, as it is balanced in men by the variety of practical needs and considerations. Even with male constituencies, particular questions are apt to become too predominant, and to lead to the exaction of tyrannical pledges and to narrow ostracism of conscientious public men. But with female suffrage there would probably be always a woman's question, of a kind appealing to sentiment, such as the question of the contagious diseases act, which demagogues would take care to provide, and which would swallow up every other question, and make a clean sweep of all public men who might refuse to take the woman's pledge. With female suffrage, the question of the contagious diseases act would probably have made a clean sweep, at the last general election, of all the best servants of the state.

Mr. Mill had persuaded himself that great capacity for government had been displayed by women, and that there was urgent necessity for bringing them into the management of the state. But he can hardly be serious when he cites as an instance of female rule a constitutional queen whose excellence consists in never doing any act of government except under the guidance of her ministers. The queens regnant or consort, before our monarchy became constitutional, who may be said to have wielded power, are the Empress-Queen Matilda, Eleanor, the wife of Henry II., Isabella, the wife of Edward II., Margaret of Anjou, Mary, Elizabeth, and Henrietta Maria. Not much can be made of this list, when it is considered that both Margaret of Anjou and Henrietta Maria were, by their temper, principal causes of civil wars, and that the statesmanship of Elizabeth has totally collapsed between Mr. Froude's first volume and his last, while her feminine relations with Leicester and other favorites have contracted a much more ominous complexion in a political as well as in a moral point of view. On the other hand, it is probable that Eleanor, the wife of Edward I., and certain that Caroline, the wife of George II., rendered, in a womanly way, high services to the state. Mr. Mill says, from his experience at the India office, that the queens in India are better than the kings. But the reason is obvious. British protection has suspended the operation of the rude checks on the vices of Indian despots, and a woman brought up in the *zenana*, though she cannot possibly be a good ruler, may well be better than a hog or a tiger.

Neither the cases of queens, however, nor those of female regents of the Netherlands, to which Mr. Mill gives so strange a turn (as though Charles V. and Philip II. had preferred females on account of their ability to male members of the house), are in point. They all belong to the hereditary system, under which these ladies were called to power by birth or appointment, and surrounded by counselors from whose policy it is scarcely possible to distinguish that of the sovereign. Under the elective system, women would have to make their own way to seats in Parliament and to office by the same means as male politicians, by canvassing, stumping, wrestling with competitors in debate; and the female character would be exposed to influences entirely different from those which operated on Isabella of Castile.

Without pressing the argument against "premiers in the family way" too far, it may safely be said that the women who would best represent their sex, and whose opinions would be worth most, would be generally excluded from public life by conjugal and maternal duty. Success with popular constituencies would probably fall to the lot, not of the grave matrons and spinsters whom Mr. Mill evidently has in view, but of dashing adventuresses, whose methods of captivating their constituents would often be by no means identical with legislative wisdom, or calculated to increase our veneration for their sex.

Mr. Mill is the real father of the whole movement; the arguments of its other champions are mere reproductions of his. Whatever biased his mind, therefore, ought to be carefully noted; and again it must be said that he was possessed by an illusion—an illusion beautiful and touching, but still an illusion—as to the political genius of his wife.

He has given us the means of judging of her speculative powers, and even they, it is evident, were not extraordinarily high.

That there are women eminently capable of understanding and discussing political questions nobody will deny. These will find a sphere in the press, through which many men exercise a power which makes it a matter of indifference whether they have a vote or not. But it by no means follows that it is expedient to put political power into the hands of the whole sex; much less that it is expedient to do so at a moment when it is morally certain that they would use their power to cancel a good deal of what has been done in their interest, as well as in that of their partners, by the efforts of the last two hundred years.

Some supporters of the movement flatter themselves that women would always vote for peace, and that female suffrage would consequently be a short method of ridding the world of war and standing armies. Such experience as we have hardly warrants this anticipation. Female sovereigns, as a rule, have not been eminently pacific. It would be difficult to find four contemporary male rulers who made more wars than Catherine II. of Russia, Maria Theresa, Madame de Pompadour (who ruled France in the name of her lover), and the Termagant, as Carlyle calls her, of Spain. It is widely believed that the late Empress of the French, inspired by her Jesuits, was a principal mover in the attack on Germany. Those who know the Southern States say that the women there are far more ready to renew the Civil War than the men. The most effective check on war is, to use the American phrase, that every one should do his own fighting. But this check cannot be applied to women, who will be comparatively irresponsible in voting for war. A woman, in fact, can never be a full citizen in countries where, as in Germany, it is part of a citizen's duty to bear arms.

Finally, it is said that there are certain specific grievances under which women labor, and which call for immediate redress, but of which redress cannot be had unless women are empowered to extort it from their husbands and brothers at the polls. Of course, if there is wrong, and wrong to half humanity, which cannot be righted in any other way, we must at once accept female suffrage, whatever perils it may entail.

In the United States the grievance of which most is heard is the tyrannical stringency of the marriage tie, which, it is alleged, gives a man property in a woman, and unduly interferes with the freedom and genuineness of affection. Some of the language used is more startling than this, and if reproduced might unfairly prejudice the case. But male Legislatures in the United States have already carried the liberty of divorce so far, that the next step would be the total abolition of marriage and the destruction of the family. The women themselves have now, it is said, begun to draw back. They have probably become aware that liberty of divorce must be reciprocal, that marriage is preëminently a restraint placed on the passions of the man in the interest of the woman, that a woman loses her charms more easily than she loses her need of a protector, and that to the children divorce is moral and social ruin. Mr. Mill demands for the "slave" the privilege of changing her master; he forgets that he would, at the same time, give the master the privilege of changing his slave.

The question, of which more is heard here, as to the right of women to the control of their own property, was one the importance of which was not likely to be fully perceived while comparatively few women earned their own bread. However, now that it is perceived, the British Legislature has at least gone so far in removing anomalies that it need not despair of seeing itself do complete justice. In the United States, male Legislatures, so far from being unwilling, display almost an exaggerated propensity to sever the interest of the wife from that of the husband. An eminent American jurist told the writer that he knew a case in which a woman was compelling her husband to work for her as a hired laborer, and another in which a woman had accomplished a divorce by simply shutting the door of the house, which was her own property, in her husband's face. After all, it must be remembered that the man remains responsible for the maintenance of the woman and her children, and that the analogy of a commercial partnership, which is in vogue with the champions of woman's right in the United States, is very far from holding good: commercial justice between themselves and their husbands is not what the women really want. It must be remembered, too, that the male has, by nature, certain advantages over the female which no legislature on earth can annul; and that it is necessary in the interest of both sexes, but especially in the interest of woman, to render the restraint of marriage acceptable, not only to persons of cultivated sensibility, but to ordinary men. If the ideal of marriage which floats in the pages of Mr. Mill were actually embodied in legislation, and the husband were stripped of all conjugal rights, and left with nothing but the responsibility of maintaining the family, it is at least possible that the result among the coarser masses of mankind might be the increase of license and the consequent degradation of women.

It is commonly said in the United States, by the Woman's Right party, that women are underpaid for their labor, and a vague hope is held out that this might be set right by female legislation. In most fields of industry women are new-comers, and on all new-comers old custom is apt at first to bear hard. Female singers, piano-forte players, novelists, painters, milliners, are not underpaid. If female clerks and school-mistresses are paid less than male clerks and school-masters, this may be partly because continuance in the calling is an element of value, and women are taken off by marriage. That a New-Yorker will persist, out of regard for the aristocracy of sex, in paying a man a high price for his labor when he can get the work done as well for less money by a woman, is not much to be apprehended. But that Legislatures, male or female, could equalize wages, few will be credulous enough to believe, though it is possible that the attempt might be made.

As to domestic cruelty, if it can be stopped by any extension of the criminal law, there is surely not the slightest reason for believing that male Legislatures are unwilling to perform that duty; though, of course, criminal legislation in this case, as in all others, to be effective, must keep terms with reason and justice. In fact, in this matter, women are probably better in the present hands than they would be in their own. The source of these infamies and horrors in ninety-nine cases out of a hundred is drink; and if the member for Marylebone, instead of tampering with the relations between the sexes, will turn his mind to the improvement and extension of the legislation commenced under the late Government against intemperance, he will deserve, in the highest degree, the gratitude of women in general, and especially of those who have the greatest claim to our sympathy.

The case of women is not that of an unenfranchised class, the interest of which is distinct from that of the enfranchised. The great mass of them are completely identified in interest with their husbands, while even those who are not married can hardly be said to form a class, or to have any common interest, other than mere sex, which is liable to be unfairly affected by class legislation. There is therefore no reason why Parliament should not do justice in any practical question relative to the rights of women which may be brought before it, as it has already done justice in several such questions, without invoking upon itself the coercion of female suffrage.—*Macmillan's Magazine.*

A BABY-FOX.

By Dr. BURT G. WILDER.

MY readers may have heard of the artist who, finding that his portrait of the "king of beasts" was not often recognized, indignantly wrote beneath it, "This is the picture of a lion." Something of like necessity exists with reference to the figure in the present article; for it is doubtful whether any one, not already familiar with fox-babies, would recognize it as the picture of one; to use the words of another, this is an "odd, snub-nosed little creature, resembling almost any animal rather than a fox." [1]

Yet the non-recognition cannot, in this case, be ascribed to any

[1] Wood's "Illustrated Natural History of Mammalia," p. 334; it is not often that so compact an expression occurs in these usually verbose volumes.

defect in the representation; for the original drawing was made by an anatomist,[1] and engraved by one[2] whose previous work upon natural history objects has convinced him of the need for accuracy and restraint of the artistic imagination.

Certainly the non-resemblance of the little one to its mother would have been enough to shake my belief in the statement of relationship, had not both the specimens and the statement come together from a naturalist[3] who received them direct from the hunters; and my first impulse was to publish the figure *incognito*, as a zoological conundrum.

The most obvious difference is in color: the throat and chest of the old fox are whitish, also the tip of the tail; the back of the ears, the front and outer surface of the paws to near the elbows and knees, are black, and there are scattered black hairs on the tail; the rest of the body is reddish brown; and as a whole the animal would be called a "*red* fox," although a stripe across the shoulders of a darker red might entitle it to the name of "cross" fox. Now, at first sight,

[1] My friend and former pupil, Dr. W. S. Barnard.

[2] Mr. Philip Barnard, of Chicago, now a student in Cornell University.

[3] Dr. J. T. Rothrock, of Wilkesbarre, Pennsylvania, now attached to one of the United States surveying expeditions.

all the young would be called "black," although the head and shoulders are brownish, and the tail is tipped with white.

In this connection it is to be noted that Audubon and Bachman [1] had once a mother and a litter of seven young foxes; the former was nearly jet black, with the tip of the tail white; three of the young were said to be black, the other four red; one of the blackest was kept alive for six months, and as it grew older the less it became like the "black," and the more like the "cross" fox; whence they conclude that both the "cross" and "black" foxes are mere varieties of the "red;" in this opinion Mr. J. A. Allen concurs.[2]

But there is something more to be said of *our* little fox and its mother: a closer examination of the former shows that there are two kinds of hair corresponding to the two colors; the body and tail, and upper parts of the legs, are thickly covered with a kind of soft wool, of a smoke-color, but the head presents longer and reddish-colored hairs; and these same hairs are scattered over the body, more thickly in front than behind; the two kinds are as thick brush-wood and saplings; under the microscope they are even more unlike; for the "wool" is crinkled, and its texture very transparent; the pith seeming to be divided by transverse partitions into a single row of nearly square spaces; the hairs, on the other hand, are straight, and two or three times as thick, and their texture much more dense, apparently from a crowding of the partitions and interspaces; and one thing more, the hairs are reddish only as far as they project above the wool, the deeper portions, like the wool, being smoke-colored. Now, the same is the case in the old fox, with this difference, that the hairs are so long and so numerous as to completely hide the woolly coat, and so give their own color to the animal; the wool presents the same appearance under the microscope as in the young one, and seems to be little if any larger, but the hairs are at least ten times as thick at their base, and taper thence gradually to the tip. We may easily imagine, then, not only that in some cases the long hairs themselves might be black throughout, but also that, as in the case mentioned by Audubon, an increase of the number of reddish-tipped hairs during growth might convert an apparently black fox into a red one.[3]

Finally, it is certain that, were the old fox to lose her hairs and retain only the wool, she would be as black as her young, excepting, perhaps, upon the head.

After the color, the next most striking difference between the old and young foxes is the *form of the head:* that of the former is remarkable for its length, and for the total lack of *forehead*, the up-

[1] "Quadrupeds of North America," vol. i., pp. 52, 53.

[2] "Catalogue of the Mammals of Massachusetts;" "Bulletin of the Museum of Comparative Zoology," No. 8.

[3] In the "Natural History of the State of New York," De Kay says (p. 45) that the young are at first covered by smoke-brown fur.

per surface being all on a level from the tip of the nose to the top of the head; while the frontal region of the young is quite prominent. The change in the form of the head is better shown by a comparison of measurements:

	Young.	Old.
Distance from tip of muzzle to a point between the ears.......	.050,[1]	.150,
Distance from tip of muzzle to a point between the eyes.......	.022,	.075,
Width of the head opposite the eyes........................	.042,	.075,

From the above we see that in the adult fox the muzzle proper is half the length of the head from the ears forward, and that the width of the muzzle from its base (opposite the eyes) is equal to its length; while in the young the length of the muzzle is less than half the length of the head from the ears, and little more than half the width of its base; so that even without the figure we should see the justice of Wood's description of the little fox as "snub-nosed."

But the figure or the specimen itself would be required to corroborate his other remark, that it "resembles almost any other animal rather than a fox."

Now, it certainly does not resemble a fox; and among dogs it could be compared only to the young, or to some of the smaller breeds. But it does remind one irresistibly of certain dog-faced monkeys or baboons; and to some degree, as Dr. Barnard suggests, of the lemurs. In either case it is worth while to bear in mind that the gap, hitherto supposed to exist between the *Carnivora* and the *Quadrumana*, has been partly bridged over by the researches of Milne-Edwards upon the "Embryology of the *Lemuridæ;*"[2] these curious little creatures, inhabiting the islands of Mauritius and Madagascar, and the adjacent coast of Africa, have been ranked as a subdivision of the *Quadrumana* on account of their arboreal habits, their prehensile limbs, and some anatomical resemblances to the monkeys; but an examination of their *placenta* has convinced Milne-Edwards that they are quite as nearly allied to the *Carnivora* as to the *Quadrumana*, and that they should form a distinct *order* between and connecting the other two; and this conclusion, he says, is supported by a comparison of the brain, the limbs, the skull, and the teeth.

Now, if this be correct, and if we admit that in *some way* our existing species have been derived from other and preëxisting forms,

[1] This is fifty millimetres (a trifle over two inches); the full stop is placed *after* the place for the number of metres, the unit of the measure of length; a comma is placed after the millimetres, thousandths of a metre. The old fox weighed 2,918. (two thousand nine hundred and eighteen grams, the full stop coming after the number of grams, the unit of weight), or about 6½ pounds; she was rather thin; foxes are sometimes taken weighing 10 and 11 pounds, but usually about 9; the young weighed about 15 ounces each (avoirdupois); ,375. ,377. and ,417. grams respectively; their eyes were not fully opened; all their ears were injured either by frost or the bites of dogs, and their form is uncertain.

[2] "Annales des Sciences Naturelles," Fifth Series, vol. xv.

then it is not at all difficult to account for the resemblance of our little fox to a monkey, or of certain monkeys to dogs, upon the supposition that both groups of animals, the *Quadrumana* and the *Carnivora*, are divergent branches from a common stock, resembling the lemurs more than either of them.

But, aside from such speculations as to the reason for the differences above alluded to, their existence is undeniable; and it is surprising to find how very few are the figures and descriptions of *young* mammals; the last scientific letter written me by Prof. Agassiz (September 10, 1873) strongly urged the importance of including, within the embryology of domesticated animals, the changes which they undergo *after birth;* and he particularly requested that the dogs, and the *wild canidæ* as well, should serve as the starting-point. Enough has been said to show that these changes are very great in the fox, and that they may furnish suggestions at least, as to origin and natural relationships.

RENDU AND HIS EDITORS.

By JOHN TYNDALL.

"Some have blamed me, and some have praised me, for the part I have acted toward Rendu. In one distinguished, but not disinterested quarter, I am charged with prejudice and littleness of spirit, to which charge I make no reply. But let it be shown to me that I have wronged any man by false accusation, and Zaccheus was not more prompt than I shall be to make restitution."—("Mountaineering in 1861.")

TO review a book is an unusual occurrence with me: other duties putting in a prior and peremptory claim. Still I could not, when honored with a request to do so, decline making the few observations which the brief time allowed me renders possible, on a volume just published under the joint auspices of Prof. George Forbes, Prof. P. G. Tait, Prof. John Ruskin, and Mr. Alfred Wills.

Science and Art here unite in denouncing a small book of mine entitled the "Forms of Water," to which reference has been already made in these pages.[1] Putting certain of its sentences into what they call "straightforward English," they draw the inference that my object in writing it was, in a more or less mean and underhand way, to "dim the lustre" of the late Principal Forbes's glacier-discoveries, to filch his laurels, and to dishonor his memory by fixing on him the charge of plagiarism." Other friends of the late Principal cannot, however, discover in the book any wickedness of this kind, while *no* friend of mine can discover it.

In the preface to the fourth edition of the "Forms of Water," published a few days ago, I state its origin, object, and spirit, and my atti-

[1] Vol. xxii., p. 484.

tude toward such criticisms as had then appeared, to be as follows: "I had been frequently invited to write on Glaciers in encyclopædias, journals, and magazines, but had always declined to do so. I had also abstained from making them the subject of a course of lectures at the Royal Institution, wishing to take no advantage of my position there, and indeed to avoid writing a line or uttering a sentence on the subject for which I could not be held personally responsible. In view of the discussions which the subject had provoked, I thought this the fairest course.

"But, in 1871, the time (I imagined) had come when, without risk of offense, I might tell our young people something about the labors of those who had unraveled for their instruction the various problems of the ice-world. My lamented friend and ever-helpful counselor, Dr. Bence Jones, thought the subject a good one, and accordingly it was chosen. Strong in my sympathy with youth, and remembering the damage done by defective exposition to my own young mind, I sought, to the best of my ability, to confer upon these lectures clearness, thoroughness, and life.

"I aimed, indeed, at nothing less than presenting to my youthful audience, in a concentrated but perfectly digestible form, every essential point embraced in the literature of the glaciers, and some things in addition, which, derived as they were from my own recent researches, no book previously published on this subject contained. But my theory of education agrees with that of Emerson, according to which instruction is only half the battle: what he calls *provocation* being the other half. By this he means that power of the teacher, through the force of his character and the vitality of his thought, to bring out all the latent strength of his pupil, and to invest with interest even the driest matters of detail. In the present instance, I was determined to shirk nothing essential, however dry; and, to keep my mind alive to the requirements of my pupil, I proposed a series of ideal ramblings, in which he should be always at my side. Oddly enough, though I was here dealing with what might be called the abstract idea of a boy, I realized his presence so fully as to entertain for him, before our excursions ended, an affection consciously warm and real.

"A German critic, whom I have no reason to regard as specially favorable to me or it, makes the following remark on the style of the book: 'This passion' (for the mountains) 'tempts him frequently to reveal more of his Alpine wanderings than is necessary for his demonstrations. The reader, however, will not find this a disagreeable interruption of the course of thought; for the book thereby gains wonderfully in vividness.' This, I would say, was the express aim of the breaks referred to. I desire to keep my companion fresh as well as instructed, and these interruptions were so many breathing-places where the intellectual tension was purposely relaxed and the mind of the pupil braced to fresh action.

"Of other criticisms, flattering and otherwise, I forbear to speak. As regards some of them, indeed, it would be a reproach to that manliness which I have sought to encourage in my pupil to return blow for blow. If the reader be acquainted with them, this will let him know how I regard them; and if he be not acquainted with them, I would recommend him to ignore them, and to form his own judgment of this book. No fair-minded person who reads it will dream that I, in writing it, had a thought of acting otherwise than justly and generously toward my predecessors, the last of whom,[1] to the grief of all who knew him, has recently passed away." I thus show how willing I was three weeks ago to let discussion cease.

How a great and good man regarded this book is shown by the following extract from a letter from the late Prof. Sedgwick, to whom I sent the first draft of the volume. I gather from the "Life and Letters" that he was a friend of Principal Forbes. The extraordinary freshness of his nature breaks through the concluding lines, which, save as an illustration of this, I should hardly have ventured to quote. There are others which I omit for obvious reasons:

"Cambridge, *January* 29, 1873.

"My dear Professor: I write to thank you for the little book upon the glaciers of the Alps you had the kindness to send to me, and for the instruction and delight its perusal gave me. . . . It shows a power of putting the subject in the clear, bright colors of daylight before the reader's eyes, and making him feel as if he were your happy companion and fellow-laborer.

"Truly and gratefully yours, A. Sedgwick."

This is the language of a philosopher who took my words as they stand, and did not think it necessary "to put that and that together," so as to convert my statements into "straightforward English."

The law of causality is now an *a priori* dictum of the human mind. There is no spontaneous generation of phenomena; and, like all other things, the book now under consideration had its antecedents. These are in great part to be found in a discussion which occurred twelve years ago regarding the scientific position of a noble but a suffering man. By his unaided genius, Dr. Robert Julius Mayer, of Heilbronn in Germany, reached the heart of a generalization, which the professional hierarchy of science in his day had failed to reach, and which in its later developments ranks as high as the principle of gravitation. For this great *Bahnbrecher* I sought recognition; but the recognition was by no means immediate, nor was my act applauded by all. Much the reverse. I was accused, not only of want of patriotism, but of "depreciation and suppression." I was charged with ignorance, and an "abuse of language." Every spark of originality was denied to Dr. Mayer. The calculation of the mechanical equivalent of heat, which I had ascribed to him, was claimed for M. Seguin, who, it was alleged, had, three years before Mayer, made the same calculation, and obtained

[1] Agassiz.

the same numerical result. These assertions were uttered with a confidence not surpassed by any thing contained in the volume just published by Mr. Macmillan. The sufficient reply to all this now is, that, since those days of strife, Dr. Mayer has received the highest rewards which the greatest scientific academies and societies in Europe could confer upon him; and that he now stands above detraction and debate, immovably fixed beside his illustrious experimental brother, Joule: a figure memorable to all time in the annals of science.

The gentle knight who in those days, with such conspicuous disaster to himself, took the field against me, is also my chief opponent now. He is the principal figure among the authors to whom I have referred, and I allude to these facts in order to bring him and his work into the causal series of contemporary phenomena, and to show cause for the warning that obstinacy of assertion on his part furnishes a by no means sufficient assurance that his assertions are objectively correct. Indeed, where we find these assertions associated with more than the usual want of sweetness and luminosity, the presumption arises that the judgment which proved entirely fallacious on a former occasion may at present, to say the least of it, be unsound.

The volume which calls forth these remarks is entitled "Theory of the Glaciers of Savoy," by M. le Chanoine Rendu; and the middle of the book is, I am happy to say, occupied by a translation of this remarkable essay—in itself a perfectly honorable and praiseworthy work. The volume opens with an introduction by Prof. George Forbes, son of the late Principal Forbes, which, measured by former discussions on this subject, is by no means immoderate in tone. Had this tone, indeed, been preserved throughout the discussion, these remarks of mine would never have been written. It is not in my nature to refuse sympathy to a son battling, as he imagines, for the honor of his father. But Prof. George Forbes has deliberately taken upon himself the responsibility of writings, samples of which shall be given further on, not with the view of maintaining his father's honor, but with the view of gratuitously sullying the honor of others. This, filial allegiance neither demands nor can excuse.

He prints some letters in his Introduction animadverting more or less upon me and my friends; but written at a time when the writers were very inperfectly acquainted with the subject on which they wrote. Dr. Whewell was from the first a warm supporter of Principal Forbes, and an equally warm opponent of Mr. William Hopkins; and, when my small labors on the glaciers came to be discussed, the preëxisting difference between these two distinguished men became intensified, in a high degree. It was Dr. Whewell who, in discussion with Mr. Hopkins, summed up my doings with the remark that I had simply taken Auguste Balmat to the summit of Mont Blanc and caused him to be frost-bitten.[1] It was he who in 1859 proposed Principal Forbes as a

[1] *Contemporary Review*, vol. xxii., p. 485.

candidate for the Copley medal,[1] which the Council of the Royal Society did not grant. He was angry at the time; but it pleases me to remember that subsequently in the Athenæum Club he renewed acquaintance with me, and gave me the benefit of his most agreeable and instructive conversation about glaciers.

The letter from Dr. Playfair can also be placed in a moment in its proper relation to other facts. A foot-note at page 195 of the first edition of "Heat as a Mode of Motion" runs thus: "Since the above was written, the 'Glaciers of the Alps' has been published, and soon after its appearance a 'Reply' to those portions of the work which referred to Rendu was extensively circulated by Principal Forbes. For more than two years I have abstained from answering my distinguished censor, not from inability to do so, but because I thought, and think, that within the limits of the case it is better to submit to misconception than to make science the arena of a purely personal controversy." Not for two years, but for ten years did I permit, for peace' sake, this misconception to continue; it refers to allegations as to omissions made against me by Principal Forbes, and disposed of at p. 498 *et seq.*, vol. xxii. of the *Contemporary Review.*

It will be seen at the place here referred to, that the strongest argument of Principal Forbes relates to a statement regarding *crevasses* made by Rendu; and Mr. George Forbes now contends for the correctness of his father's views. I can assure him, in all good temper and good faith, that he is hopelessly wrong; that his father entirely misapprehended Rendu; and that the argument founded on this misapprehension, though apparently so incontrovertible, and so damaging to me, is in reality not worth the paper on which it stands. During the lifetime of Principal Forbes I never once disturbed him in the enjoyment of his delusive triumph, and my life also would have passed without any attempt at refutation had not his biographers flaunted the argument again in my face, and compelled me to reduce it to the condition in which it appears in my last article. Had I, as alleged, been disposed to wound Principal Forbes, I should not have acted thus.

I had stated in the "Glaciers of the Alps," and in this Review, that some very important measurements made by Agassiz in 1841 and 1842, by which the differential motion of a glacier was demonstrated, had been ignored in all the writings of Principal Forbes. Though so much occupied with the subject, I was in absolute ignorance of the existence of these measures myself until my attention was drawn to them by Sir Charles Wheatstone, immediately before the publication of the "Glaciers of the Alps." Prof. George Forbes now charges me with forgetfulness of the fact that it was his father who suggested to M. Agassiz the measurements he made; meaning thereby, I suppose, to intimate that his father was not called upon to recognize measurements which were the result of his own instruction.

[1] On this subject, *see* Prof. Huxley's masterly letter in *Nature,* May 22, 1873.

I would, however, ask Mr. Forbes to consider whether I, while endeavoring to hold the balance fairly between contending claims, should have been justified in accepting his father's assertion and ignoring the diametrically opposite assertion of Agassiz? On this point I would direct his attention to two sources of information; the one probably known to him, the other unknown, and which the desire not to inflame this controversy has prevented me from publishing hitherto.

In the first place, I will make a brief extract from a very rare *brochure* published by Agassiz, in evident affliction of mind, in 1842. In that pamphlet he addresses thus his guest of the previous autumn:

"What eloquence have I not wasted in order to cause you to accept such and such a conclusion; what lengthened excursions, extending over days, have I not made to convince you of such and such a fact? And what advantage did I derive from nearly a month of these labors? This solely. On every new subject of discussion you favored me with the profound reflections: it is very curious; it is very extraordinary; it is most remarkable; it is capable of various interpretations; various causes might have produced these effects! Never a word on the true basis of the question. And, notwithstanding this, I told you all, showed you all, even things regarding which I had published nothing."

I was in duty bound to give due weight to this side of the question; and in 1859, prior to the publication of the "Glaciers of the Alps," I wrote to M. Agassiz, inquiring whether he still maintained the position here assumed; which, it will be seen, not only touches, but *is*, the very point brought forward by Prof. George Forbes. I will give the pith of his reply, which, as just intimated, has lain beside me unpublished for fifteen years. After sketching the "incredible difficulties" of his early glacier campaigns, his uncertainty regarding the measurement of the motion of bowlders, his failure on the Aar, and Escher's failure on the Aletsch, to determine the motion of a series of stakes fixed in 1840, because, through ignorance of the amount of ablation, they did not sink them deep enough in the ice, Agassiz answers me thus:

"It was not until after my second visit to the Aar in the winter of 1840–'41 that I felt myself prepared for a systematic experimental investigation of the glacier; and I then went up, not with the hope of solving all the problems in one year, but with the view of laying the basis of a solution. The fact that I staked a series of poles across the whole width of the glacier, to a depth which left them standing to the following year, and that I then went up with an experienced engineer to make a minute map of the entire surface of the glacier, which was executed, will show that I had laid my plans for a successful survey of glacier phenomena before Prof. Forbes had, for the first time, set his foot upon the glaciers with a view to studying them.

"When I invited him to spend some time with me upon the glacier in 1841, I hoped to receive some valuable hints for my investigations from a physicist of so high a standing as his. But he never suggested any thing to me, while I showed him every thing I had been doing, explained all my difficulties, and the devices with which I proposed to overcome them. That Prof. Forbes reached the Mer de Glace in 1842, a few weeks before I went up the Glacier of the Aar, only gave him the opportunity of making a few days' observations at a time when I had already gained an annual average. *That Prof. Forbes knew in* 1841 *of my intention to make this experiment I can affirm the more positively as he saw the iron bars with which I intended to bore the holes, and which had been carried up the glacier before he reached the Grimsel.* That I was going to use instruments of precision in these measurements he must have understood, since I repeatedly mentioned my purpose of making a trigonometrical survey of the glacier the following year. Whether I at any time mentioned the theodolite I cannot remember now. But I am sure that he never suggested any thing to me.

"Allow me one more remark. Everybody knows that I am a naturalist, and not a physicist. My interest in the glaciers arose from a desire to learn something of the mammoth of Siberia, after I had become convinced by Charpentier that the glaciers of Switzerland were much more extensive in earlier times than now. It struck me that there might be some connection between the burial of these gigantic mammalia in the arctic regions and the wider range of glaciers in Switzerland; I am one of those who believe, as you expressed it in your short and characteristic speech at Geneva, that 'Nature is One,' and so I was led to study the accumulations of ice without the necessary preparation. This you cannot fail to perceive in reading the accounts of my successive attempts, and for this, I hope, some allowance will hereafter be made."

This account fairly tallies with the statement of Prof. Forbes in his "Travels," quoted in his "Life" (p. 503):

"Far from being ready to admit, as my sanguine companions wished me to do in 1841, that the theory of glaciers was complete, and the cause of their motion certain, after patiently hearing all that they had to say, and reserving my opinion, I drew the conclusion that no theory which I had then heard of could account for the few facts admitted on all hands, and that the very structure and motions of glaciers remained still to be deduced from observation."

Incomparably greater than Forbes in his own field, the want of physical knowledge, to which Agassiz refers at the conclusion of the foregoing letter, rendered him, on this particular ground, a mere child in comparison with his guest. Still, if the statement which I have italicised in Agassiz's letter express a fact, then, while entertaining no doubt that Prof. Forbes justified his conduct to his own mind, I leave it to others to judge whether it would not be an evil day for the frankness of scientific intercourse if such conduct should become general.

It is difficult at the present day and hour to convey an idea of the stir caused by the communication of our joint paper to the Royal Society by Mr. Huxley and myself; but many of us remember the violent discharge of letters which followed that event. Had I in those days a tendency to be puffed up, the circumstances were certainly such as might exalt my self-importance. But, as a matter of fact, the whole business was exceedingly saddening to me. For two years I endeavored, while not flinching from what I held to be the duty of a scientific man, to turn away by soft answers the wrath excited against me. I failed to do so. The tone of depreciation indulged in was typified by the remark of Dr. Whewell above quoted, and threats of punishment were everywhere rumored. I refer to these almost forgotten occurrences, which need never have been revived, to show how natural it would have been for me to assume in the "Glaciers of the Alps" a more decidedly controversial tone than that actually assumed in it.

Many of the claims then made for Principal Forbes were perfectly inconsistent with the facts known to me. Sir Charles Wheatstone had pointed out those measurements to which Agassiz refers as having been begun under Prof. Forbes's eyes, and which were more than ignored. I had also read Rendu's Essay, and found there matters absolutely unknown to the supporters of Principal Forbes, and directly at variance with statements current in high quarters. I also noticed, or thought I noticed, a tendency, glanced at in my former article, to regard the self-same data as important or unimportant according as they were employed by Forbes or Rendu.

Let me illustrate my meaning here. One of the strongest passages cited by Principal Forbes to show that he had recognized the merits of Rendu, which I never denied, but expressly admitted, is this ("Travels," page 382): "The idea of comparing a glacier to a river is any thing but new, and I would not be supposed to claim that comparison or analogy as an original one. Something very like a conception of fluid motion seems to have been in the minds of several writers, although I was not aware of it at the time that I made my theory. In particular, M. Rendu, whose mechanical views are in many respects more precise than those of his predecessors or contemporaries, speaks of 'glaciers d'Écoulement' as distinct from 'glaciers Reservoirs,' and in the quotation at the head of this chapter he contemplates the *possibility* of the mutual pressures of the parts overcoming the rigidity. He is the only writer of the glacier school who has insisted on the plasticity of the ice, shown by moulding itself to the endlessly varying form and section of its bed; and he is also opposed to his leading contemporaries in his conjecture that the centre of the ice-stream would be found to move fastest. But," and here comes one of those qualifying phrases to which I have already referred,[1]—"M. Rendu has the candor not to treat his ingenious speculations as leading to any certain result, not being founded on experiments worthy of confidence."

I will ask permission to go one step farther. At the British Association Meeting at York, that able mathematician and high-minded gentleman, Mr. W. Hopkins, got into a sharp discussion with Prof. Forbes regarding the viscous theory, and he, subsequently, wrote upon the subject in the *Philosophical Magazine*. In the same journal Forbes published a reply; one of the strongest points of which, if

[1] *Contemporary Review*, vol. xxii., p. 507.

not the very strongest point, is the following. Speaking of the principle of plasticity, Prof. Forbes writes:

"Perhaps the following illustration will appear to the impartial reader almost a demonstration of this principle. . . . There is a glacier basin in the range of Mont Blanc called the Glacier du Talèfre. Its outline is correctly represented in the next figure, as well as the relative dimensions of the mouth or outlet by which it pours forth the mass of ice which it is annually unable to contain in its circuit. The breadth of the outlet is about seven hundred yards, while the greater diameter of the basin which it discharges is more than forty-two hundred yards, or at least six times greater. Can it for one moment be imagined that any degree of *lubrication* of the bed of this cake of ice could drag it through the strait in question, even if its adhesion to the soil were absolutely nothing? The thing is impossible; it speaks for itself." [1]

The observation here referred to as so convincing is precisely of that class upon which Rendu founded his theory; and there cannot be a reasonable doubt that the very fact here brought forward more or less influenced him. Still, while in the hands of Prof. Forbes it has the value here set forth, in those of Rendu the "ingenious speculations" founded upon it are not "worthy of confidence."

It is not, and never was, my design to charge Principal Forbes with conscious wrong; but, at the time here referred to, I believed him to be animated by a love of public recognition so eager, and an estimate of the value of his own work so exalted, as to render it difficult for him to behave in a generous way toward those whose labors trenched upon his own. I regarded his treatment of Agassiz as harsh, if not merciless. Considering all this, I do not think that the "Glaciers of the Alps," written in the midst of such contentions as I have indicated, can be justly deemed intemperate in tone. Its logic is sometimes stern; [2] but its statements are irrefutable. To its chapters, from page 269 onward, I would refer the reader for an answer to a good deal of the irrelevant bluster associated with this question.

I am blamed for saying that, if Rendu had added to his other qualifications those of a land-surveyor, he would now be deemed the "Prince of Glacialists." Can this be for a moment doubted? When we find him announcing, with a fullness and precision never surpassed, and not attained even by Prof. Forbes himself until years after the publication of his "Travels," the character of glacier-motion; when we find him laboriously trying to determine it by observations of blocks at the edge and toward the middle of the glacier—is it to be imagined that, if he knew the use of the theodolite, he would not have employed that instrument? And is the absence of this surveyor's knowledge a just reason for dismissing his labors in the fol-

[1] *Philosophical Magazine*, vol. xxvi., pp. 414, 415.

[2] What a courteous demeanor might have done to modify this, I cannot now say, but I know that, after the death of Principal Forbes, no reference of mine to his work or memory lacked appreciation or kindness.

lowing fashion in the "Life and Letters of Principal Forbes?" After having referred to the Dilatation and Gravitation Theories, and to an observation of Playfair's, the writer proceeds: "We are not aware that any thing of particular importance beyond this was known, in the sense of having been *observed*, not merely *seen*, till Forbes took up the subject, with the exception of Rendu's acute remark, which appears to have been previously made by Captain Basil Hall and others, that a glacier seems to flow in its channel like a sluggish stream." This is as inadequate as it is unjust; and I would also, once for all, respectfully protest against the following language as describing with even approximate fairness the relation of Rendu to this question: "One of the few men who seems in any point of consequence to have had even one clear and accurate idea on the subject before Forbes is Mgr. Rendu, late Bishop of Annécy, but this was so mixed up with error that it does not appear likely that in his hands it could have ever led to any thing definite; for Rendu holds and enunciates, sometimes in the same sentence, facts and errors utterly incompatible with them." [1] This is the spirit of depreciation which has introduced bitterness into these discussions, and which will not be shared by any just or generous mind.

Prof. Tait has prepared himself for his portion of the book here under review by some researches which prove that a "grudge on my part against Prof. Forbes was in full bud as early as 1854." He moreover credits me with "extremely great skill in choosing precisely such forms of language as were calculated to produce the most exquisite torture in the mind of a scrupulously upright and high-souled man." That I should exhibit skill in any thing is to me astonishing. What he here says, coupled with what he had said before regarding my ignorance, is a mere feeble copy of his description of Mr. Lowe—a man "compounded in about equal proportions of fiend and fool;" and such repetition is unworthy of the versatile genius of Prof. Tait. Speaking seriously, we have, in both cases, the mere wildness of uncontrolled anger. I had no more grudge against Prof. Forbes in 1854 than against Prof. Faraday, and friendly letters passed between Forbes and myself long subsequent to this date. In fact, if I had any grudge, it was rather against Agassiz than against Forbes, for in those days I was impatient with Agassiz's physics, but otherwise ill acquainted with the merits of the case between them. Might I commend to my critic the following deliverance of his distinguished countryman Prof. Bain? "Our emotions of *anger*, like fear, are manifestations superinduced upon mere pain. Revenge, antipathy, hatred, party spirit, are so many forms of the irascible feeling, and are antagonistic in a conspicuous degree to the ascertaining of truth. Calumny, the expression of anger, connotes falsehood."

I willingly accept Prof. Tait's grammatical correction as regards

[1] Prof. Tait in "Life and Letters of Forbes," pp. 494, 498.

the introduction of two articles, and the substitution of the word "mutual" for "natural" in the statement of the viscous theory. Such mistakes readily escape me in the reading of proofs with the meaning of which I am very familiar; and some similar errors in my other works, discovered mainly by my own pupils, await correction in subsequent editions. In the "Glaciers of the Alps," my critic will find "mutual" all right, and one of the indefinite articles supplied. But the shifting of the vowel to a consonant was overlooked, and the second article was therefore omitted.

From the level of the irascible, Prof. Tait on one occasion rises to that of exultation. "While we write," he exclaims, "another actor has appeared on the scene—and with tremendous effect. The terrible words of Mr. Ruskin (Fors Clavigera, Letter xxxiv.), with regard to Dr. Tyndall and his 'Forms of Water,' will reach myriads of intelligent readers besides those who could otherwise be expected to interest themselves in a question involving scientific issues. Mr. Ruskin's admirable command of language, his clearness, impartiality, acuteness, and his exemplary firmness in declaring truth, and doing justice, leave nothing to be desired."

These are strong words. What is their value? Let a very able sample of Mr. Tait's countrymen reply. "He" (Prof. Tait), says the *Scotsman* of April 24th, "may be occasionally shy in his substantives, but he has no timidity in his adjectives. 'Contemptible,' 'unutterably contemptible,' 'miserable,' 'disgusting,' 'shabby,' 'pernicious,' 'pestilent,' 'hideous,' are among the projectiles, more natural perhaps than philosophical, which the Professor of Natural Philosophy distributes round him." But whence, it may be asked, this exorbitant jubilation? What on earth can the opinion of Mr. Ruskin have to do with the solution of a question which has stood in the fierce light of scientific discussion for fourteen years? Is it to be imagined that he has found something which has escaped Helmholtz or Sedgwick? Surely, if Prof. Tait will only give his clouds of anger time to disappear, he will see the absurdity of introducing such loose rhetoric among grave students of science.

Further on we have Principal Forbes's pure and disinterested love of knowledge for its own sake, contrasted with that of others who seek it for the sake of notoriety. Let me examine this notion in the light of a crucial instance.

In walking up the glacier of the Aar with Agassiz, Prof. Forbes observed blue veins running through the ice. Agassiz had noticed the grooves answering to them on the surface, but he had not studied them, and in all likelihood he blundered in his conversation about them with his acute and physically-cultured guest. They followed these veins subsequently together for several days, and, after the departure of Forbes, Agassiz traced them to a depth of a hundred and twenty feet. Humboldt, I am informed, had been instrumental in getting him pecuniary aid for his researches, and to Humboldt, after the glacier campaign of 1841 had ended, he addressed a *private* note, mentioning among other things his having seen the veins. I make no attempt at excusing his omission of the name of Forbes from this note; but, taking every thing into account, the sin of omission does not seem very heinous. Its effect upon Prof. Forbes shall be described by himself.

"I reached home," he says, "in the month of October, 1841, and soon commenced the historical review of the glacier question which I had projected. While I was thus engaged, the 'Comptes Rendus' of the Academy of Sciences in Paris for the 18th of October reached me. In it I found a letter from M. Agassiz to Baron Humboldt, containing the following passage with reference to the observations made upon the glacier of the Aar:

"'Le fait le plus nouveau que j'ai remarqué, c'est la présence dans la masse de la glace des rubans verticaux de glace bleue, alternant avec des bands de glace blanche d'un quart de ligne à plusieurs pouces de large, s'étendant sur toute la longueur du glacier et penetrant à une profondeur du moins 120 pieds puisque j'ai observé encore ce phénomène au fond du trou de sonde.'

"On reading this letter," says Principal Forbes, "from which even all mention of my presence on the Aar is excluded, my first impression was of surprise and pain. That I could not suffer so direct a plagiarism to remain unchallenged never appeared to me to admit of a doubt; *le fait le plus nouveau que* J'AI *remarqué* was an assertion as articulate as it was unfounded."

For nearly a month Prof. Forbes had shared the shelter of Agassiz's roof, and wandered with him among scenes of unsurpassed grandeur. He had found in his host "noble ardor, generous friendship, unvarying good temper, and true hospitality." It is upon the man thus described by himself that Prof. Forbes turns in this fierce way, for the mere omission of his name. It grieves me to say a word which could be interpreted as severe to a dead man; but the comparisons drawn by his panegyrist compel me to state that, among the eminent men whom it is my privilege to call my friends, there is not one to whom such an explosion of resentment for so purely personal—I had almost said paltry—a cause would be even approximately possible. I charge him with nothing consciously unfair; but from a man so hot in the assertion of his "claims," so sensitive to public recognition, and so free in the use of hard words, these interminable discussions run as naturally as rivers from their water-shed.

With more time at my disposal I should probably enter more fully into these matters; but this and my former article, taken in conjunction with the "Forms of Water," in which, even to the ignoring of myself, I desire to do justice both to Agassiz and Forbes, and the pages referred to in the "Glaciers of the Alps," will have so far cleared a dusty atmosphere as to enable any really earnest reader to see the bearings of this question. It now only rests with me to give some samples of those "terrible" and "tremendous" words to which Prof. Tait has referred, and which Prof. George Forbes has thought fit to make a portion of his volume. Forty years ago, Mr. Ruskin first saw the Alps from Schaffhausen.

"Only one great step," he says, "in the knowledge of glaciers has been made in all that period; and it seems the principal object of Prof. Tyndall's book to conceal its having been taken, that he and his friends may get the credit, some day, of having taken it themselves. . . . At the end of the last book of his he" (Prof. Tyndall) "denies, as far as he dares, the essential points of Forbes's discovery. . . . The readers of 'Fors' may imagine they have nothing to do with personal questions of this kind, but they have no conception of the degree in which general science is corrupted and retarded by those jealousies of the schools; nor how important it is to the cause of all true education that the criminal indulgence of them should be chastised. Criminal is a strong word, but an entirely just one. I am not likely to overrate the abilities of Prof. Tyndall; but he had at least intelligence enough to know that his dispute of the statements of Forbes by quibbling on the word viscous was as uncandid as it was unscholarly; and it retarded the advance of glacier science for at least ten years. . . . And the absurdity, as well as the iniquity, of the professor's willful avoidance of this gist of the whole debate is consummated in this last book, in which, though its title is the 'Forms of Water,' he actually never traces the transformation of snow into glacier-ice at all."

If these "terrible" words be *true* words, why was it left to an amateur to utter them? Why were they not uttered years ago by Prof. Tait himself? To these and other observations of Mr. Ruskin I offer no reply; nor should I have ever given them the slightest regard or attention were it not for the use which a scientific man has stooped to make of them.

"Fors Clavigera" has but a scanty circulation—how, then, were the "myriad intelligent readers" of Prof. Tait obtained? Simply by circulating "Fors" in Scotland, and republishing Mr. Ruskin's article in the Scotch newspapers. Prof. Tait, moreover, was for some years attached to Queen's College, Belfast, and I am to have the honor of presiding at the meeting of the British Association to be held next August in that city. Accordingly, the article in "Fors" has been republished in the Belfast journals also. The *Northern Whig* and the *Belfast Newsletter* have duly reached me with Mr. Ruskin's article conspicuously marked. These are some of the amenities of Prof. Tait: others are at hand, but I refuse to notice them. The spirit which prompts them may, after all, be but a local distortion of that noble force of heart which answered the "Cameron's gathering" at Waterloo; carried the Black Watch to Coomassie; and which has furnished Scotland with the materials of an immortal history. Still, rudeness is not independence, bluster is not strength, nor is coarseness courage. We have won the human understanding from the barbarism of the past; but we have won along with it the dignity, courtesy, and truth of civilized life. And the man who on the platform or in the press does violence to this ethical side of human nature discharges but an imperfect duty to the public, whatever the qualities of his understanding may be.—*Contemporary Review.*

THE CHAIN OF SPECIES.

By Hon. LAWRENCE JOHNSON.

PART II.

WHEN Wolf, Goethe, Oken, and Geoffroy St.-Hilaire began to tell us that the method of the creation of living creatures is an evolution, it was far from satisfactory. To comprehend the proposition in the first place was exceedingly difficult. It was almost incomprehensible, indeed, to minds tutored in the anthropomorphic notions of spasmodic and arbitrary special efforts on the part of some Demiurgus. Educated to see in Nature what were called evidences of design, meaning plan and purpose according to our finite ideas of design, we could not rise to the conception of the continuous action of universal law; and every thing not easily construed by our preconceived teleology was settled by the convenient doctrines of miracles and cataclysms. In another way, also, the world was not prepared for the proposition; for, in the second place, the proofs were hidden away in the still undiscovered facts of homology. The science of morphology was yet to be created. Not yet was it known that Bryant's solemn verses—

"All that tread
The globe are but a handful to the tribes
That slumber in its bosom"—

are as applicable to the genera and species of all living creatures as to the individuals of the human race; that the organic forms now extant are in simplest truth insignificant, both as to numbers and varieties, when compared with those which have preceded them and which have perished forever.

No wonder, then, that the new-fledged doctrine of evolution soon went out of fashion when even the great disciples of the great leaders just mentioned, Lamarck and the elder Darwin, had no better explanation to offer than the hypothesis of transmutation. Yet it ought not to be forgotten that their principal opponents were not devout professors of religion and theology, to the really qualified of whom, it must have been indifferent; but Voltaire, Frederick II., Cuvier, and Agassiz, men whom no one ever suspected of any profound knowledge of theology, or of special reverence for its deductions.

But now the mists are clearing away, just as, according to the logic of things, we should expect. For there is evolution in human thought and comprehension, as in all things else. Yet the how—the question of the method—the process of the development of life—still confronts us; and the recent labors of Charles Darwin, Wallace, Voght, Haeckel, Cope, and others, have taught us that the answer is not to be jumped at by mere speculation, nor by hasty inference from the sparse and ill-digested facts of natural history now in our possession. The full solution of the mystery still lies in the future, and is to be reached only after the collection and comparison of a mass of data overwhelming to contemplate. In the mean time, confusion of ideas and differences about words characterize all our controversies. How men will misunderstand one another!

> "We have an idea, make a word,
> Too false t' unite us, or control;
> And for the word itself we fight
> In bitterness of soul."—WORDSWORTH.

It is usual to state that there are two theories of the origin of species, of the production of organic forms, namely, the theory of special creations, and the theory of natural selection. But the statement stands in need of criticism. The supposition of a special genesis, whether by some assumed *ab extra* influence, in other words, miraculous interference, or by some influence working *ab intra*, is a virtual begging of the question, a virtual admission that we never can follow the chain of causation. And this, because at some stage of the process the battle is to be stopped; at some step of the argument our mouths are to be shut, if not with a miracle after the manner of the Sunday-school teachers, which has at least the merit of piety about it, then with the more formidable obstruction of an *inexplicable* fact or property. And we are actually told, by one of this turn of thinking, that "to bother ourselves about these inexplicable facts is as irrational as to discuss the politics of the moon."

But, leaving special genesis aside, let us consider a little more closely the doctrine of natural selection. This, in fact, is not a theory of the origin—of the genesis of species. As M. Quatrefages has remarked, it is not a theory at all, for it explains nothing, accounts for nothing, and is not therefore truly an hypothesis in philosophy. Natural selection is not a cause, but the discussion of it draws attention to the chain of causes at the bottom of which we must look for the solution of our problem. As we all know, it is a notion taken from the selection exercised by the hand of man in the rearing of domestic plants and animals. Man, by the conscious or unconscious selection of that which best suited his wants or caprices, has educed and displayed many varieties of living creatures; and in like manner it is suggested that Nature, by holding on to the fittest in the struggle for life, has herself made selection of the innumerable forms we see. In a general way, this principle has always been recognized; and in past ages it has been always remarked that the varieties discovered are well adapted to exist, and that, if they were not so adapted, they would perish. But we have yet to see that these variations are always the fittest, or that the fittest comparatively always survive.

But, indeed, so far as Mr. Darwin puts forth a theory at all, it is not that natural selection is the cause of species; but that slight accidental variations occur from some unknown or inexplicable cause; and that by natural selection the fittest of these will survive.

There is not so much difference after all between the two so-called theories as it is common to believe; the inexplicable accident brings them together at last. It is only the using of different words for the same notion. Variation, by slight accidental degrees, is quite as unphilosophical as the production of species, by decided *saltus* or springs, from some innate miraculous cause. Suppose, then, we drop the question of the origin of species and the cause of variation, and try to observe and understand the different stages of the growth and evolution of such living creatures as the earth is filled with, whether fittest or unfittest: would not this be much more consistent with the vocation of science? In itself it will be a delight, whether it solves any thing or not.

Assuming matter and its law or properties—and remember, again, that without them it would not be matter—how, and by what steps, and stages, and degrees, has it put on the myriad forms of life?

We will not enter into those deeper speculations of philosophy which range every thing in unity or duality—which divide Nature into matter and force—or look upon the cosmos as one substance under two aspects, static and dynamic; and regard matter, in mathematical language, as composed of points in space and time; or, using purer ontological phrases, as centres of *force* or *motion* under the cosmical relations of time and space. Nor is it necessary to draw comparisons between these conceptions. They are but doctrines of method, and for certain purposes one may use either. Neither is this the place to dwell upon the forces, their correlation, and their unity; nor upon the principles of physics as a science. All this will be assumed as generally understood.

Matter we have; now life!

Suppose every thing prepared—a home, the earth, fitted to receive the invited guest; whence the mysterious power, vitality? The altar is prepared, the wood cleaved, and the sacrifice laid thereon: how was the fire from heaven invoked?

Recollect this maxim of even the old scholastic philosophy: that, having matter and form—that is, Nature and its laws—we are not to search outside of these, for we need no other factors to account for all the metamorphoses this basement matter may assume.

The first appearance of organic life—the stealing of this first fire from heaven—this is the easiest step in the whole process; easiest, naturally, because nearest to the inorganic kingdom, which is so much less complicated than the organic; easiest, because, as we advance, the factors which enter into the calculation and bear upon the result become so numerous and obscure that we never can know when we have discovered the half of them; much less their interminable combinations. And yet, as to organic life in general, is it not confessed that, if we could only account for the existence of the cell, of that first morsel of colloid matter, we should have the key to all its mysteries?

Very well. What is a cell? Or, expressed in other words, what is that drop—that particle of matter, called now by that same old fashion of supplying phrases when ideas fail—protoplasm? What is protoplasm?

For aught we know, there may be monads or gemmules of organic creatures, as conjectured by Mr. Spencer and Mr. Darwin, there may be a peculiar substance endowed with life as a property, as conjectured by Mr. Huxley, there may be these atoms of organic life—the bases of organizations; and organized creatures may be definite arrangements of these, for aught we know. But really, except as a provisional theory, used, as we see it in the notion of Pangenesis put forth by the great naturalist, merely to aid in rising to other conceptions, there is very little need for such a supposition. Especially is it to be used guardedly. For, while put forth expressly in analogy to the atomic theory in chemistry, which is an aid to grasp the law of definite proportions, it is to be feared that many will so lean upon the crutch, they may never learn to walk. We know that in chemistry this is true; that many possessed of feeble powers of abstraction rest in the doctrine of atoms as the final fact; as in religion feeble minds stop at the forms and images used, and fail to comprehend the Deity taught and concealed thereby.

Rightly understood, the doctrines of Protoplasm, of Gemmules, *et id omne genus*, if they aid little, can do little harm. For, to the physiologist, there remains the great fact that *organization is life*. In, through, and by means of organization, or, if you prefer it, an organism, is matter endowed with life. So far as physiology, and therefore natural science and physics, is concerned in this matter, life does not exist without organization. Now, then, what is the first, the simplest form of organization—the primordial type of organic creatures? It is a cell. For, notice what is really meant by an organism—an organized creature. It is a creature that has functions dependent upon organs or parts. There is, then, in the very simplest organism already a manifestation of Von Baer's great law in biology—*differentiation*. Without differentiation there is no organization, and without organization, again, no life.

It is impossible to stop here to dwell upon the organization of a cell, and the proofs of it in unicellular creatures. This has been more fully treated of in some of my earlier productions. Still, a glance at this question—how? whence?—was promised.

See, then, this drop of colloid matter—this protoplasm—this cell. It can scarcely be called protoplasm until there is organization; and, if so, then it is what the older anatomists called a cell. Can there be colloid matter without organization? Both chemistry and physiology answer in the affirmative. It may and does so exist in abundance. But it yet remains to be shown that the substance itself, *and all the other necessary external circumstances*, can meet without producing or exhibiting *life*. Not that our experiments have ever shown a single instance of the fact. But it has never in the failures been shown that every necessary concurrent circumstance was also applied. Far have every one of the experiments been from the least pretense to a perfect repetition of the exact circumstances which in the beginning did actually witness the genesis of the germs of life. Now that we have these germs we think it easier to understand their successive reproduction than their primal genesis. How far this is from the fact we have already noted.

When we have a morsel, a drop of nitrogenized colloid matter, we can easily comprehend how the attacks of oxygen will cause the evolution of those forces which again will cause a difference of functions in different parts; which, again, by this very differentiation become organs. Without a differentiation there would be no relation of the parts; no polarity; no motion; no circulation; no duplication; no increase—the best evidence of the presence of organic life. In our most ordinary notion of a cell there is all of this; and this motion, this polarity, this circulation, can be caused by oxygen alone, attacking a suitable compound. A circulation, which is but a repetition of rhythmical motion, once set up, organization is complete. Endow this organization with continuity, or the power of repeating itself, which the rhythmical circulation and polarity are capable of doing; endow it with the power of inspiring other colloid and crystalloid atoms with like vibrations, attracting them into its own mass, and then ejecting them again, arranged in form like to the original cell, which it will continue to do from habit, and you have living creatures.

Comparatively simple as this is, we are not so much concerned at present with the origin of life as with its metamorphoses. Having life in the shape of cells, and the first must be hypothetical, how does it advance? This is biological science.

The advance of life is also simple. It progresses by characteristics which must distinguish all organization, whether of organic or of inorganic elements—cosmical, chemical, or social. It is by aggregation, as Mr. Spencer has it—by a compounding. By compounding, and by differentiation; these are the two great laws.

The primordial cell, by holding on to the new broods of cells as they seek to escape from the parent hive—by retaining them and giving them a new division of labor for the common family—compounds and increases the energy of the common organism.

Every living creature, as we now know these creatures, is a compound. Simplicity is nowhere. Even the simplest the microscope can show is probably already a compound of many removes from the beginning.

The law of compounding is not at all mysterious. If the first force of reproduction, the genesis of individuals, exhibits itself in the form of an evolution—a budding forth, a repetition of the form and structure of the parent cell—the law of compounding first presents itself as an *arrestation* of the law of gemmation. The old cell fails in force to throw off the new one; or, by another law, equally in force, adhesion takes place between the contiguous surfaces of the old and the new, and the extrusion to complete independence cannot be effected. This is the simple rule extending up through all the shining ranks and files of life. In the higher forms this law presents itself in the form of involution; but in lower creatures it is but an adhesion—an anchylosis. In all it is a *failure* of a perfect evolution—a failure perfectly to develop and reproduce a separate cell.

Now that we have the laws, let us see if we comprehend their application in Nature's workings. Really we might go to mathematics, and take from geometry, not only illustrations, but the very definitions of biology. Geometry, first and simplest of the sciences, begins its definitions with a point; from a point it proceeds to a line; from a line to a surface; from a surface to a solid. In biology, beginning with a cell, which is the physiological point or unit; the next development is to an axis, a line of cells, the type of all baculate structures. This baculus revolved upon itself, phyllate structure—a biological surface, the type of all organisms having one depth of cells. The next step is to the biological solid. This is made by an involution, a folding down of the surface upon itself, constituting a creature of two laminæ—two tiers of cells.

Passing on to another class, typically displayed for instance in hepaticæ, we find that another involution has taken place. This time the phyllum of two tiers of cells is folded upon itself, constituting one normally of four layers. Here first occur those curious openings into the centre of the structure known as stomata, rendered necessary, of course, from the fact that two of the strata are internal, and but for these contrivances would be cut off from that direct contact with atmospheric air which is necessary to the life of external living creatures. The next and the last evolution which takes place in the ascending development of plants is the folding upon itself of this leaf of four thicknesses of cells, so as to make a sheet consisting essentially of eight thicknesses of cells—the type of all the so-called higher plants. In this respect exogens and endogens do not differ; their only real difference being the atrophy and suppression of one cotyledon of the former to constitute the latter. In exogens there may be, in addition to these, various subordinate adhesions, but no further involutions of the whole creature. These may be called topical, as affecting only portions of the compound structure; and among endogens, from the rolling up of the single phyllate cotyledon, these adhesions must be innumerable. Otherwise there would be no stems to plants of this class. A careful analysis will always enable us to trace the original layers, and, wherever reduced to a simple leaf, to find the law invariable.

It is manifest that all these creatures live externally. The leaf is the type of all; and every metamorphosis is some modification of a leaf. Even creatures of a single cell may be regarded as diminutive leaves; and all leaves are compounds of simple cells. The point is, the true manner of organization or of life. The grand peculiarity of all of them is that the great disturber—life-destroyer and life-giver, atmospheric oxygen—must come in direct contact with each and every cell. Organisms living in this way are called plants—a term which has no scientific meaning or value, since it indicates no relation to other creatures. All other living creatures constitute but one other grand kingdom; animals, another unscientific term. Unscientific as the terms are, it is generally supposed that we know pretty well to what they apply. We understand these are the first two branches from the main root of organic life, springing from the same original germ, and expanding into two great trees, never uniting nor mingling their boughs any more. It is easy to see the correlation of these two; the true distinction between them.

The so-called plant never loses the type or plan of the original leaf, of the primitive cell. It always remains phyllate, and living, as it were, cell by cell, in external relations to the air and the sources of nutrition. The so-called animal is more complicated. It differentiates completely the points, or spots, or organs of aëration and of nutrition; devotes one part of the organism to nutrition, and another to oxygenation. This is not all. Thus far probably all cells agree. But in animals the organs and functions of nutrition, at least, are in some fold of the tegument or sarcode, so that they store away their food in a special receptacle, and carry it about. This is as perfectly true of the most elementary amœba as of the elephant. This view of the ground of classification has been rejected by naturalists—by Dr. Carpenter among others; but this was done years ago, inconsiderately, and without the aid of recent advances in biology.

The amœba, although a mere drop of jelly, *improvises* a pocket, or stomach, for the reception of its food, which, for the time being, is differentiated to nutrition. The so-called plant, on the contrary, has its mesentery, as well as its apparatus for aëration, external to the organism. The animal involutes a part of its investing tegument; takes the mesentery, at least, into the inside of the body; and, in the higher orders, the lungs also.

The scientific relations of the two kingdoms are well indicated, therefore, in the terminology which classifies the one as *Exothens*—external livers; and the other as *Endothens*—internal livers.

As to their life, and the elements of organization, they are precisely the same. The same chemical constituents, the same protoplasm, the same basement of cell-growth, and the same compounding of cells, characterize the development of both. In short, there is but one set of organic creatures. They are all animals, or all plants, as you may please to call them.

Before this simple distinction into endothentic and exothentic, all the difficulties, of discriminating in special cases as to which of the two great kingdoms has the best claim to a particular species, vanish. Those organisms of the boundary-line which could never be located, because sometimes apparently one, and sometimes the other, as motion and volition, seemed to be present or absent, now readily take their places. For instance, the aëthalium—to show the impossibility of a definite boundary—is sometimes observed as a flying vibrio, then a crawling amœba-like drop of sarcode; then, in the still condition, a greenish spherical cell like some protococus; even this mysterious creature need no longer be regarded as amphibious. In every stage it is decidedly exothentic.

What, then, is the distinction, and how does the evolution advance? Let us go back a little. We observe that in plants evolution advances by a folding down of the creature upon itself—an involution. A strip of paper may well represent that type which consists of a single tier or layer of cells, as in ulvaceæ; or even baculate types, as confervæ. This is our biological surface.

Fold it down upon itself, the two surfaces coming in contact soon adhere, and then we have, as we have seen, a creature of two tiers of cells. This begins to look like reducing a loose collection, or a mere association of cells, to a consolidated organization.

Fold the sheet again, and you have another solid, a creature of four tiers of cells, with a distinct axis of growth. This is the type of all the higher cryptogams.

Fold it once more, and you have a type, normally, of eight tiers—the type of the phanerogams.

It is to be noted that every folding develops a new axis of growth at right angles to that of the preceding type, the folding being really the mechanism employed for the evolution of the axis. Involutions do not stop here, for no surfaces come together without a tendency to adhere, especially in the fœtal stage of life when all the elements are plastic; and it is at that period that all variations occur. But, as already noticed, no further involutions, except these three, affect the axis of the whole creature and change the type. To this simple fact of the adhesion of organic surfaces all the innumerable morphological variations may be referred. Upon it depends the success of the surgeon's skill, as well as the analysis of the speculative physiologist. Adhesions of the edges of leaves account for their shapes and sizes. Adhesion by their surfaces causes many wonders, among them the evolution of all carpels, seeds, and fruits. Sometimes, also, there is adhesion of surfaces confined to a single leaf, as in the *iris*. But these adhesions are all topical, if I may use the word, and do not affect the type and general axis.

Now, this involution, by which the progress of evolution takes place, may, as remarked, and strange to say, be described as a *failure of development*—a failure to unfold into the original type, constituting, by the very failure, a new and higher type. If we watch the development of any leaf from venation, we observe that in some way it was folded down upon itself, or rolled up with its fellows of the same bud, and before coming to adult age it expanded into the recognized form of its order. Let but that expansion fail, and the evolution may be said to fail. A happy failure; for to this we owe the production of grain and fruit—the food of man. Adhesions take place within the buds, which change the leaf-buds into flower-buds. The change is always made in the embryo, while still plastic and capable of being moulded into new forms.

It would be delightful to follow the immortal Linnæus, Wolf, Goethe, and the grand army of enlightened living botanists, who have illustrated this beautiful transcendental history of leaves, and flowers, and fruits; but time forbids at present. Suffice it to say that, so far as the vegetal kingdom is concerned, the doctrines of involution have become the common property of the scientific world.

Let us pass on to the so-called animal kingdom.

And first, as to the bridge we cross. True, it is somewhat the fashion to tell us that here is a great gulf fixed, and no crossing was ever possible. Yet Nature found a bridge somewhere, and we ought not to despair of finding at least some remains of the abutments.

To illustrate this passage from the vegetal to the animal plan of structure, take a hollow India-rubber ball, which may very well represent a cell enlarged a few thousand diameters. It is a perfect image of an external living creature, and is also typical of one stage of the development of the ova of the lower orders of animals—probably of all animals. But it is the adult form of plants. The vital functions of such a cell are all within; and there is no communication with the external world, except by osmotic action. Through this same cell-wall—this same external coat—and by means of it, nutrition and aëration are both carried on. This is an *exothen*.

Now, by pressing the finger upon a part of the elastic coat, a portion of it sinks in, and you have a cup—a cup with double walls and a space between them. This is an involution; and by means of such an involution as this Nature transforms a plant into an animal.

Recently-published observations of Kowalewsky declare that he has seen this sort of transformation actually take place in the growth of the embryo of a creature as high in the scale as the Ascidians. Doubtless, in Nature, the true process was a failure at one point to fill out the rounded fullness of the ball; some contraction, some atrophy, some failure to grow at a certain spot, while the balance of the creature continues its development, until a wall arises around the constriction and becomes permanent, further growth only increasing the introversion—precisely such a process as we may witness at the hands of a potter when he places a ball of clay upon his wheel. First he flattens the top of his ball; then, as he continues to press upon the point, the adjacent clay rises around it; and next you have a cup. And such a cup-like cell is the type of all endothentic creatures; that is, of all animals.

Naturalists, it is true, regarding only flagrant forms, confine the term *cœlenterate* to one class; those that are *permanently* open-cupped. But, strictly, all differentiate a part of the investing tegument into a cup, for the purpose of carrying about their nutrition; and, however much the cup may be extended and contorted—drawn out into a tube and folded away into some convenient receptacle, and puckered, and tucked, and furnished with a thousand little pockets supplementary—it is all but an extension of that same original internal fold or cup. Finally, in the highest animals, all the principal vital functions are found severally the office of some pocket of the integument *involuted* and shoved out of sight and out of harm's way into the great cavity.

Having obtained for our animal kingdom the cupped cell as a type, we have plain sailing for some time.

In the outset, we may subdivide the kingdom into the *occasionally* cupped and the *permanently* cupped. Those that present the cup as occasion serves, or only in one stage of their evolution, are exemplified in the Rhizopoda. The permanently-cupped include not only those always open-mouthed—the cœlenterata of Mr. Huxley—but, as we have seen, necessarily all of the higher classes.

Observe, again, the India-rubber ball. First, we have the cup. Now, this open cup is mouth—is stomach—is vent—is every thing. Every thing that goes into the creature enters here; all that comes out finds exit by means of this common gap. Soon Nature, so to speak, finds this plan poor economy, and divides off one side, or edge of the cup, for one purpose, another for another purpose, and we find one corner or edge of it devoted to the entrance of nutrition, another to the exit of the *débris*. Nor is this mere speculation. Creatures are actually so constituted, and are seen to develop to this type from the *ovum.* We often see, in cœlenterates, as in sea-anemone, a tendency to the same thing. Now, this very fact of voiding *indigesta* at one angle of the mouth, while the other is receiving a fresh supply of food, produces a constriction in the unused middle region; and the consequence is that here the lips approximate one another, and finally, adhering at the point of contact, a permanent *perinæum-like* septum is formed.

This adhesion completed, nothing more is wanting to exhibit the type of the higher *animalia;* for here is a complete alimentary canal, however short, and a dorsal and a ventral aspect. This is an animal of one segment, or cell, type of both the cœlenterata and molluscoida of Mr. Huxley, and of all mono-segmental creatures.

Henceforward, this type is the unit of animal organisms, as a simple cell is the unit of primary vegetal life. For want of a better term such a creature may be called a mono-segmentary, consisting of but one segment or unit; while all others are polysegmentarian—consisting of more sections than one.

Nature retains her *habits* very tenaciously. If we have seen her rising to higher and higher types of vegetal structure by adding cell to cell; duplicating cells by division and holding on to them by adhesion; extending them by increase upon one axis into a baculus; upon two axes into thalli; and folding them again into fronds, leaves, and fruit—we no less see her handling this new unit of organization in a similar manner. Ay! the parsimonious *builder* again goes through precisely the same means of progress. She works by compounding; by multiplication of segments; by gemmation; by the evolution of higher types; by a failure to expel the simple segments; until, by adhesions in fœtal life, a more complex creature is formed of multiplied powers.

Here, again, we come to great gulfs and faults in the strata, which naturalists tell us cannot be bridged over. There remain still the three highest types of organic creatures to be accounted for, namely, the *annulosa*, or *articulata*, the *mollusca*, and the *vertebrata*. Our most eminent recent naturalists regard all these as unconnected with preceding forms, and unconnected with one another. Some of the very recent, as Haeckel, endeavor to show a consistent chain here by connecting directly molluscoids with vertebrates; dropping out of the series entirely the two great classes of mollusca and articulata, and leaving their evolution unaccounted for. True, there can be no objection to leaving them out of the chain, if they have no place in it. If we can arrive at vertebrates and man directly from the holothurius, well and good. It would be analogous to other proceedings of Nature, as in the separate evolution of the whole grand vegetal kingdom from the first living germs, in a direction exactly opposite, as it were, to animal evolution. But we should also account for the genesis of the two eccentric classes, and connect them in some way with primordial types.

COLOR IN ANIMALS.

THE variety of coloring in animal life is one of the marvels of Nature, only now beginning to be studied scientifically. It is vain to say that an animal is beautiful, either in symmetry or diversity of color, in order to please the human eye. Fishes in the depth of the Indian seas, where no human eye can see them, possess the most gorgeous tints. One thing is remarkable: birds, fishes, and insects, alone possess the metallic coloring; while plants and zoophytes are without reflecting shades. The mollusca take a middle path with their hue of mother-of-pearl. What is the reason of these arrangements in the animal kingdom? It is a question which cannot be satisfactorily answered; but some observations have been made which throw light on the subject. One is, that among animals, the part of the body turned toward the earth is always paler than that which is uppermost. The action of light is here apparent. Fishes which live on the side, as the sole and turbot, have the left side, which answers to the back, of a dark tint; while the other side is white. It may be noticed that birds which fly, as it were, bathed in light, do not offer the strong contrast of tone between the upper and lower side. Beetles, wasps, and flies, have the metallic coloring of blue and green, possess rings equally dark all round the body; and the wings of many butterflies are as beautifully feathered below as above.

On the other hand, mollusca which live in an almost closed shell, like the oyster, are nearly colorless; the larvæ of insects found in the ground or in wood have the same whiteness, as well as all intestinal worms shut up in obscurity. Some insects whose life is spent in darkness keep this appearance all their lives; such as the curious little beetles inhabiting the inaccessible crevasses of snowy mountains, in whose depths they are hidden. They seem to fly from light as from death, and are only found at certain seasons, when they crawl on the flooring of the caves like larvæ, without eyes, which would be useless in the retreats where they usually dwell.

This relation between coloring and light is very evident in the beings which inhabit the earth and the air; those are the most brilliant which are exposed to the sun; those of the tropics are brighter than in the regions around the north-pole, and the diurnal species than the nocturnal; but the same law does not apparently belong to the inhabitants of the sea, which are of a richer shade where the light is more tempered. The most dazzling corals are those which hang under the natural cornices of the rocks and on the sides of submarine grottoes; while some kinds of fish, which are found on the shores as well as in depths requiring the drag-net, have a bright-red purple in the latter regions, and an insignificant yellow brown in the former. Those who bring up gold-fish know well that, to have them finely colored, they must place them in a shaded vase, where aquatic plants hide them from the extreme solar heat. Under a hot July sun they lose their beauty.

The causes to which animal coloring is due are very various. Some living substances have it in themselves, owing to molecular arrangement, but usually this is not the case; the liveliest colors are not bound up with the tissues. Sometimes they arise from a phenomenon like that by which the soap-bubble shows its prismatic hues; sometimes there is a special matter called pigment which is united with the organic substance. Such is the brilliant paint, carmine, which is the pigment of the cochineal insect, and the red color of blood, which may be collected in crystals, separate from the other particles to which it is united.

Even the powder not unknown to ladies of fashion is one of Nature's beautifying means. That which is left on the hands of the ruthless boy, when he has caught a butterfly, is a common instance; but there are birds, such as the large white cockatoo, which leave a white powder on the hands. An African traveller speaks of his astonishment on a rainy day to see his hands reddened by the moist plumage of a bird he had just killed. The most ordinary way, however, in which the pigment is found is when it exists in the depths of the tissues reduced to very fine particles, best seen under the microscope. When scattered, they scarcely influence the shade; but, when close together, they are very perceptible. This explains the color of the negro: under the very delicate layer of skin which is raised by a slight burn there may be seen abundance of brown pigment in the black man. It is quite superficial, for the skin differs only from that of the European in tone; it wants the exquisite transparency of fair races. Among these, the colors which impress the eye do not come from a flat surface, but from the different depths of layers in the flesh. Hence the variety of rose and lily tints according as the blood circulates more or less freely; hence the blue veins, which give a false appearance, because the blood is red; but the skin thus dyes the deep tones which lie beneath it; tattooing with Indian-ink is blue, blue eyes owe their shade to the brown pigment which lines the other side of the iris, and the muscles seen under the skin produce the bluish tone well known to painters.

The chemical nature of pigment is little known; the sun evidently favors its development in red patches. Age takes it away from the hair when it turns white, the coloring-matter giving place to very small air-bubbles. The brilliant white of feathers is due to the air which fills them. Age, and domestic habits exchanged for a wild state, alter the appearance of many birds and animals; in some species the feathers and fur grow white every year before falling off and being renewed; as in the ermine, in spring the fur which is so valued assumes a yellow hue, and, after a few months, becomes white before winter.

It would, however, be an error to suppose that all the exquisite metallic shades which diaper the feathers of birds and the wings of butterflies arise from pigments; it was a dream of the alchemists to try to extract them. Their sole cause is the play of light, fugitive as the sparkles of the diamond. When the beautiful feathers on the breast of a humming-bird are examined under the microscope, it is astonishing to see none of the shades the mystery of which you would penetrate. They are simply made of a dark-brown opaque substance not unlike those of a black duck. There is, however, a remarkable arrangement; the barb of the feather, instead of being a fringed stem, offers a series of small squares of horny substance placed point to point. These plates, of infinitesimal size, are extremely thin, brown, and, to all appearance, exactly alike, whatever may be the reflection they give. The brilliant large feathers of the peacock are the same; the plates are only at a greater distance, and of less brightness. They have been described as so many little mirrors, but that comparison is not correct, for then they would only give back light without coloring it. Neither do they act by decomposing the rays which pass through them, for then they would not lose their iris tints under the microscope. It is to metals alone that the metallic plumage of the humming-birds can be compared; the effects of the plates in a feather are like tempered steel or crystallized bismuth. Certain specimens emit colors very variable under different angles, the same scarlet feather becoming, when turned to ninety degrees, a beautiful emerald green.

The same process which Nature has followed in the humming-bird is also found in the wing of the butterfly. It is covered with microscopic scales, which play the part of the feather, arranged like the tiles of a house, and taking the most elegant forms. They also lose their color under magnifying power, and the quality of reflection shows that the phenomena are the same as in feathers. There is, however, a difference in the extent of the chromatic scale. While the humming-bird partakes in its colors of the whole of the spectrum from the violet to the red, passing through green, those of the butterfly prefer the more refrangible ones from green to violet, passing through blue. The admirable lilac shade of the *Morpho menelas* and the *Morpho cypris* is well known, and the wings of these butterflies have been used by the jewelers, carefully laid under a thin plate of mica, and made into ornaments. A bright green is not uncommon, but the metallic red is rare, excepting in a beautiful butterfly of Madagascar, closely allied to one found in India and Ceylon. The latter has wings of a velvet black with brilliant green spots; in the former, these give place to a mark of fiery red.

There is the same difference between the metallic hues of creatures endowed with flight and the iris shades of fishes, that there is between crystallized bismuth and the soft reflections of the changing opal. To have an idea of the richness of the fish, it is only necessary to see a net landed filled with shad or other bright fish. It is one immense opal, with the same transparency of shade seen through the scales, which afford the only means of imitating pearls. It is due, however, not to the scales, but to extremely thin layers lying below the scales under the skin and round the blood-vessels, which look like so many threads of silver running through the flesh. Réaumur first noticed and described them; sometimes their form is as regular as that of a crystal, and of infinitesimal size and thickness. The art of the makers of false pearls is to collect these plates in a mass from the fish, and make a paste of them with the addition of glue, which is pompously named "Eastern essence." This is put inside glass beads, and gives them the native whiteness of pearls.

Many observations have been made lately by our naturalists as to the defense which color supplies to animals: hares, rabbits, stags, and goats, possess the most favorable shade for concealing them in the depths of the forest or in the fields. It is well known that when the Volunteer corps were enrolled, and the most suitable color for the riflemen was discussed, it was supposed to be green. Soldiers dressed in different shades were placed in woods and plains, to try which offered the best concealment. Contrary to expectation, that which escaped the eyes of the enemy was not green, but the fawn color of the doe. Among hunting quadrupeds, such as the tiger, the leopard, the jaguar, the panther, there is a shade of skin which man has always been anxious to appropriate for his own use. The old Egyptian tombs have paintings of the negroes of Soudan, their loins girt with the fine yellow skins for which there is still a great sale. All the birds which prey upon the smaller tribes, and fishes like the shark, are clothed in dead colors, so as to be the least seen by their victims.

There is an animal which, for two thousand years, has excited the curiosity and superstition of man by its change of color—that is, the chameleon. No reasonable observation was ever made upon it, until Perrault instituted some experiments in the seventeenth century. He observed that the animal became pale at night, and took a deeper color when in the sun, or when it was teased; while the idea that it took its color from surrounding objects was simply fabulous. He wrapped it in different kinds of cloth, and once only did it become paler when in white. Its colors were very limited, varying from gray to green and greenish brown.

Little more than this is known in the present day; under our skies it soon loses its intensity of color. Beneath the African sun, its livery is incessantly changing; sometimes a row of large patches appears on the sides, or the skin is spotted like a trout, the spots turning to the size of a pin's head. At other times, the figures are light on a brown ground, which a moment before were brown on a light ground, and these last during the day. A naturalist speaks of two chameleons which were tied together on a boat in the Nile, with sufficient length of string to run about, and so always submissive to the same influences of light, etc. They offered a contrast of color, though to a certain degree alike; but, when they slept under the straw chair which they chose for their domicile, they were exactly of the same shade during the hours of rest—a fine sea-green that never changed. The skin rested, as did the brain, so that it seemed probable that central activity, thought, will, or whatever name is given, has some effect in the change of color. The probability is that, as they become pale, the pigment does not leave the skin, but that it is collected in spheres too small to affect our retina, which will be impressed by the same quantity of pigment when more extended.

It is undoubtedly the nerves which connect the brain with organs where the pigment is retained. By cutting a nerve, the coloring-matter is paralyzed in that portion of the skin through which the nerve passes, just as a muscle is isolated by the section of its nerve. If this operation be performed on a turbot when in a dark state, and thrown into a sandy bottom, the whole body grows paler, excepting the part which cannot receive cerebral influence. The nerves have, in general, a very simple and regular distribution; if two or three of these are cut in the body of the fish, a black transversal band following the course of the nerve will be seen; while, if the nerve which animates the head is thus treated, the turbot, growing paler on the sand, keeps a kind of black mask, which has a very curious effect.

These marks will remain for many weeks, and what may be called paralysis of color has been remarked in consequence of illness or accident. Such was seen in the head of a large turbot, the body being of a different color. It was watched, and died after a few days, evidently of some injury which it had received. The subject offers a field of immense inquiry; the chemical and physical study of pigments, the conditions which regulated their appearance, their intensity, and variations under certain influences; the want of them in albinos, and the exaggerated development in other forms of disease. To Mr. Darwin, and to M. Ponchet, in France, the subject is indebted for much research, which will no doubt be continued as occasion offers.—*Chambers's Journal.*

AN ESTIMATE OF DARWIN.

By Professor ASA GRAY.

TWO British naturalists, Robert Brown and Charles Darwin, have, more than any others, impressed their influence upon Science in this nineteenth century. Unlike as these men and their works were and are, we may most readily subserve the present purpose in what we are called upon to say of the latter by briefly comparing and contrasting the two.

Robert Brown died sixteen years ago, full of years and scientific honors, and he seems to have finished, several years earlier, all the scientific work that he had undertaken. To the other, Charles Darwin, a fair number of productive years may yet remain, and are earnestly hoped for. Both enjoyed the great advantage of being all their lives long free from any exacting professional duties or cares, and so were able in the main to apply themselves to research without distraction and according to their bent. Both, at the beginning of their career, were attached to expeditions of exploration in the Southern Hemisphere, where they amassed rich stores of observation and materials, and probably struck out, while in the field, some of the best ideas which they subsequently developed. They worked in different fields and upon different methods; only in a single instance, so far as we know, have they handled the same topic; and in this the more penetrating insight of the younger naturalist into an interesting general problem may be appealed to in justification of a comparison which some will deem presumptuous. Be this as it may, there will probably be little dissent from the opinion that the characteristic trait common to the two is an unrivaled scientific sagacity. In this these two naturalists seem to us, each in his way, preëminent. There is a characteristic likeness, too—underlying much difference—in their admirable manner of dealing with facts closely and at first hand, without the interposition of the formal laws, vague ideal conceptions, or "glittering generalities," which some philosophical naturalists make large use of.

A likeness may also be discerned in the way in which the works or contributions of predecessors and contemporaries are referred to. The brief historical summaries prefixed to many of Mr. Brown's papers are models of judicial conscientiousness. And Mr. Darwin's evident delight at discovering that some one else has "said his good things before him," or has been on the verge of uttering them, seemingly equals that of making the discovery himself. It reminds one of Goethe's insisting that his views in morphology must have been held before him and must be somewhere on record, so obviously just and natural did they appear to him.

Considering the quiet and retired lives led by both these men, and the prominent place they are likely to occupy in the history of Science, the contrast between them as to contemporary and popular fame is very remarkable. While Mr. Brown was looked up to with the greatest reverence by all the learned botanists, he was scarcely heard of by any one else; and out of botany he was unknown to Science except as the discoverer of the Brownian motion of minute particles, which discovery was promulgated in a privately-printed pamphlet that few have ever seen. Although Mr. Darwin had been for twenty years well and widely known for his "Naturalist's Journal," his works on "Coral Islands," on "Volcanic Islands," and especially for his researches on the Barnacles, it was not till about fifteen years ago that his name became popularly famous. Ever since no scientific name has been so widely spoken. Many others have had hypotheses or systems named after them, but no one else, that we know of, a department of bibliography. The nature of his latest researches accounts for most of the difference, but not for all. The Origin of Species is a fascinating topic, having interests and connections with every branch of Science, natural and moral. The investigation of recondite affinities is very dry and special; its questions, processes, and results alike—although in part generally presentable in the shape of morphology—are mainly, like the higher mathematics, unintelligible except to those who make them a subject of serious study. They are especially so when presented in Mr. Brown's manner. Perhaps no naturalist ever recorded the results of his investigations in fewer words and with greater precision than Robert Brown: certainly no one ever took more pains to state nothing beyond the precise point in question. Indeed, we have sometimes fancied that he preferred to enwrap rather than to explain his meaning; to put it into such a form that, unless you follow Solomon's injunction and dig for the wisdom as for hid treasure, you may hardly apprehend it until you have found it all out for yourself, when you will have the satisfaction of perceiving that Mr. Brown not only knew all about it, but had put it upon record long before. Very different from this is the way in which Mr. Darwin takes his readers into his confidence, freely displays to them the sources of his information and the working of his mind, and even shares with them all his doubts and misgivings, while in a clear and full exposition he sets forth the reasons which have guided him to his conclusions. These you may hesitate or decline to adopt, but you feel sure that they have been presented with perfect fairness; and, if you think of arguments against them, you may be confident that they have all been duly considered before.

The sagacity which characterizes these two naturalists is seen in their success in finding decisive instances, and in their sure insight into the meaning of things. As an instance of the latter on Mr. Darwin's part, and a justification of our venture to compare him with the *facile princeps botanicorum*, we will, in conclusion, allude to the single instance in which they took the same subject in hand. In his papers on the organs and modes of fecundation in Orchideæ and Asclepiadeæ, Mr. Brown refers more than once to C. K. Sprengel's almost forgotten work, shows how the structure of the flowers in these orders largely requires the agency of insects for their fecundation, and is aware that "in Asclepiadeæ . . . the insect so readily passes from one corolla to another that it not unfrequently visits every flower of the umbel." He must also have contemplated the transport of pollen from plant to plant by wind and insects, and we know from another source that he looked upon Sprengel's ideas as far from fantastic. Yet, instead of taking the single forward step which now seems so obvious, he even hazarded the conjecture that the insect-forms of some Orchideous flowers are intended to deter rather than to attract insects. And so the explanation of all these and other extraordinary structures, as well as of the arrangement of blossoms in general, and even the very meaning and need of sexual propagation, were left to be supplied by Mr. Darwin. The aphorism "Nature abhors a vacuum" is a characteristic specimen of the Science of the middle ages. The aphorism "Nature abhors close fertilization," and the demonstration of the principle, belong to our age, and to Mr. Darwin. To have originated this, and also the principle of Natural Selection—the truthfulness and importance of which are evident the moment it is apprehended—and to have applied these principles to the system of Nature in such a manner as to make, within a dozen years, a deeper impression upon natural history than has been made since Linnæus, is ample title for one man's fame.

There is no need of our giving any account or of estimating the importance of such works as the "Origin of Species by means of Natural Selection," the "Variation of Animals and Plants under Domestication," the "Descent of Man, and Selection in relation to Sex," and the "Expression of the Emotions in Man and Animals"—a series to which we may hope other volumes may in due time be added. We would rather, if space permitted, attempt an analysis of the less known but not less masterly subsidiary essays, upon the various arrangements for insuring cross-fertilization in flowers, for the climbing of plants, and the like. These, as we have heard, may before long be reprinted in a volume, and supplemented by some long-pending but still unfinished investigations upon the action of Dionæa and Drosera—a capital subject for Mr. Darwin's handling.

A propos to these papers, which furnish excellent illustrations of it, let us recognize Darwin's great service to Natural Science in bringing back to it Teleology: so that, instead of Morphology *versus* Teleology, we shall have Morphology wedded to Teleology. To many, no doubt, Evolutionary Teleology comes in such a questionable shape as to seem shorn of all its goodness; but they will think better of it in time, when their ideas become adjusted, and they see what an impetus the new doctrines have given to investigation. They are much mistaken who suppose that Darwinism is only of speculative importance and perhaps transient interest. In its working applications it has proved to be a new power, eminently practical and fruitful.

And here, again, we are bound to note a striking contrast to Mr. Brown, greatly as we revere his momory. He did far less work than was justly to be expected from him. Mr. Darwin not only points out the road, but labors upon it indefatigably and unceasingly. A most commendable *noblesse oblige* assures us that he will go on while strength (would we could add health!) remains. The vast amount of such work he has already accomplished might overtax the powers of the strongest. That it could have been done at all under constant infirm health is most wonderful.

Appended is a full List of Mr. Darwin's Works.

GENERAL WORKS.

Journal of Researches into the Natural History and Geology of the Countries visited by H. M. S. Beagle, 1845.

On the Origin of Species by Means of Natural Selection, 1859.

This was preceded by a sketch, entitled "On the Variation of Organic Beings in a State of Nature;" published in the *Journal of the Linnæan Society*, vol. iii. (Zoology), 1859, p. 46.

The Variation of Plants and Animals under Domestication. 2 vols. 1868.

The Descent of Man, and Selection in relation to Sex. 2 vols. 1871.

The Expression of the Emotions in Man and Animals. 1872.

ZOOLOGICAL WORKS.

The Zoology of the Voyage of H. M. S. Beagle, edited and superintended by C. Darwin, 1840; consisting of five parts.

A Monograph of the Cirripedia, Part 1, Lepadidæ; Ray Society, 1851, pp. 400.

A Monograph of the Cirripedia, Part 2, the Balanidæ; Ray Society, 1854, pp. 684.

A Monograph of the Fossil Lepadidæ; Pal. Society, 1851, pp. 86.

A Monograph of the Fossil Balanidæ and Verrucidæ; Pal. Society, 1854, pp. 44.

Observations on the Structure of the Genus Sagitta; Annals of Natural History, vol. xiii., 1844.

Brief Descriptions of Several Terrestrial Phanariæ, and of Some Marine Species; Annals of Natural History, vol. xiv., 1844, p. 241.

BOTANICAL WORKS.

On the Various Contrivances by which British and Foreign Orchids are fertilized, 1862.

On the Movements and Habits of Climbing Plants; Journal Linnæan Society, vol. ix., 1865 (Botany), p. 1.—This paper has also been published as a separate work.

On the Action of Sea-water on the Germination of Seeds; Journal Linnæan Society, vol. i., 1857 (Botany), p. 130.

On the Agency of Bees in the Fertilization of Papilionaceous Flowers; Annals Natural History, vol. ii., 1858, p. 459.

On the Two Forms or Dimorphic Condition of the Species of Primula; Journal Linnæan Society, vol. vi., 1862 (Botany), p. 77.

On the Existence of Two Forms and their Reciprocal Sexual Relations in the Genus Linum; Journal Linnæan Society, vol. vii., 1863 (Botany), p. 69.

On the Sexual Relations of the Three Forms of Lythrum; Journal Linnæan Society, vol. viii., 1864, p. 169.

On the Character and Hybrid-like Nature of the Illegitimate Offspring of Dimorphic and Trimorphic Plants; Journal Linnæan Society, vol. x., 1867 (Botany), p. 393.

On the Specific Difference between *Primula veris* and *P. vulgaris*, and on the Hybrid Nature of the Common Oxslip; Journal Linnæan Society, vol. x., 1867 (Botany), p. 437.

Notes on the Fertilization of Orchids; Annals Natural History, September, 1869.

GEOLOGICAL WORKS.

The Structure and Distribution of Coral-reefs, 1842; pp. 214.

Geological Observations on Volcanic Islands, 1844; pp. 175.

Geological Observations on South America, 1846; pp. 279.

On the Connection of the Volcanic Phenomena in South America, etc.; Transactions of Geological Society, vol. v.; read March, 1838.

On the Distribution of the Erratic Bowlders in South America; Transactions of Geological Society, vol. vi., read April, 1841.

On the Transportal of Erratic Bowlders from a Lower to a Higher Level; Journal Geological Society, 1848, p. 315.

Notes on the Ancient Glaciers of Caernarvonshire; Philosophical Magazine, vol. xxi., 1842, p. 180.

On the Geology of the Falkland Islands; Journal Geological Society, 1846, pp. 267.

On a Remarkable Bar of Sandstone off Pernambuco; Philosophical Magazine, October, 1841, p. 257.

On the Formation of Mould; Transactions of Geological Society, vol. v., p. 505; read November, 1837.

On the Parallel Roads of Glen Roy; Transactions of Philosophical Society, 1839, p. 39.

On the Power of Icebergs to make Grooves on a Submarine Surface; Philosophical Magazine, August, 1855.

An Account of the Fine Dust which often falls on Vessels in the Atlantic Ocean; Proceedings of Geological Society, 1845, p. 26.

Origin of the Saliferous Deposits of Patagonia; Journal of Geological Society, vol. ii., 1838, p. 127.

Part Geology; Admiralty Manual of Scientific Inquiry, 1849. Third edition, 1859.—*Nature.*

SKETCH OF THE LIFE OF DR. PRIESTLEY.

IT is unnecessary to call attention to the eloquent and impressive lecture by Dr. Draper which opens the present number of THE POPULAR SCIENCE MONTHLY. It will be read with avidity and pleasure by all classes as a beautiful tribute to a noble man, and as treating one of the most brilliant of scientific discoveries with the true poetic inspiration which well befits so grand a theme. Dr. Draper's statement is as fresh and felicitous as if his lecture had just been prepared to commemorate the centennial of the Discovery of Oxygen, and but few will suspect on perusing it that it was delivered a quarter of a century ago, before the medical students of the New York University; of course with no reference whatever to the present occasion. It was privately printed by the class for their own use, and has never before been given to the public. Its perusal cannot fail to sharpen the interest of readers to know more of the personality of the remarkable man who made the greatest of all chemical discoveries, and to whose eventful career there attaches so romantic an interest. The materials of the following sketch are compiled from the summary of Priestley's work given by Dr. Thomas Thomson, in his history of chemistry in 1829, and from the "Autobiography and Life of Priestley," published by his son in 1807.

Joseph Priestley was born in 1733, near Leeds, in Yorkshire, England. His father was a poor mechanic, a cloth-dresser, and his mother the daughter of a farmer. He was the eldest child, and, having lost his mother when six years of age, he went to live with his aunt, a woman in good circumstances, without children, and who adopted him. She was a dissenter, and her house was the resort of all the dissenting ministers in the country; and it is important to observe that, although a very religious woman, she was so thoroughly liberal as to welcome even the most unorthodox clergymen to her hospitality, and to encourage the widest latitude of opinion—a circumstance which probably determined the career of her nephew. Joseph was sent to a public school in the neighborhood, and at sixteen had made considerable progress in Latin, Greek, and Hebrew. He had thoughts of studying for a clergyman, but, his health failing, he turned his attention to trade, with the idea of settling in Lisbon as a merchant. This induced him to study the modern languages, and he learned French, Italian, and German, without a master. Recovering his health, he abandoned the business scheme, and resumed his former plan of becoming a minister. Having made some progress in mechanical philosophy and metaphysics, and dipped into Chaldee, Syriac, and Arabic, and learned a system of short-hand, in 1752 he was sent to the academy at Daventry. Here he spent three years, engaged keenly in studies connected with divinity, and wrote some of his earliest theological tracts. Freedom of discussion was admitted to its full extent in this academy, and the discussions among the students were conducted with perfect good-humor on both sides. Young Priestley, as he tells us himself, usually supported the heterodox opinion; but he never at any time, as he assures us, advanced arguments which he did not believe to be good, or supported an opinion which he did not consider as true.

When he left the academy, he settled at Needham, in Suffolk, as an assistant in a small, obscure dissenting meeting-house, at a salary of $150 a year. From the outset he was an original and independent thinker, and as a preacher he gave free and conscientious expression to the views he was led to adopt. It could hardly be otherwise than that such a course would be distasteful to many people whose religion consisted in the acceptance of a system of dogmatic theology. Hence his hearers fell off at Needham, from their dislike of his theological opinions. He attempted a school, but the scheme failed because of his unpopularity. Several pulpit vacancies occurred in his vicinity, but he was treated with contempt and thought unworthy to fill any of them. Even the dissenting clergy in the neighborhood considered it a degradation to associate with him, and durst not ask him to preach, not from any dislike to his opinions, for several of them thought as freely as he did, but because the genteeler part of their audiences always absented themselves when he appeared in the pulpit. A good many years afterward, when his reputation was high, he preached in the same place, and multitudes flocked to hear the very same sermons which they had formerly listened to with contempt! Leaving Needham, he went to Nantwich, where he preached for three years; and, by teaching twelve hours a day much of the time, was able to purchase a few books and some philosophical instruments, as a small air-pump, an electrical machine, etc. These he taught his eldest scholars to keep in order and manage; and by entertaining their parents and friends with experiments, in which the scholars were generally the operators, and sometimes the lecturers too, he considerably extended the reputation of his school. At this time he wrote a grammar, which is said to have been an excellent work; but the favorable reception of Dr. Louth's grammar, published about the same time, prevented its general circulation. He practised flute-playing, and, although not a proficient, he found it serviceable as a recreation, and recommended music to all studious persons for this purpose.

From Nantwich he went to Warrington in 1761, where he spent six years in teaching. He here entered zealously upon the prosecution of his systematic studies and his researches. He wrote a variety of works, prominent among which was his history of electricity. In relation to the origin of this work he remarks: "On going to London[1] I met Dr. Franklin, and was led to attend to the subject of experimental philosophy more than I had done before; and having composed all the lectures I had occasion to deliver, and finding myself at liberty for any undertaking, I mentioned to Dr. Franklin an idea that had occurred to me of writing the history of discoveries in electricity, which was his favorite study. This I told him might be a useful work, and that I would willingly undertake it, provided I could be furnished with the books necessary for the purpose. This he readily undertook, and, my other friends assisting him, I set about the work without having the least idea of doing any thing more than writing a distinct and methodical account of all that had been done by others. Having, however, a pretty good machine, I was led, in the course of my writing

[1] He always spent one month in every year in London, which was of great use to him. He generally made additions to his library and his chemical apparatus. A new turn was given to his ideas, and new and useful acquaintances were made.

the history, to endeavor to ascertain several facts which were disputed; and this led me, by degrees, into a large field of original experiments, in which I spared no expense that I could possibly furnish. These experiments employed a great proportion of my leisure time; and yet, before the complete expiration of the year in which I gave the plan of my work to Dr. Franklin, I sent him a copy of it in print." It was this work which first brought him into notice as an experimental philosopher and procured for him the title of Doctor of Laws from the University of Edinburgh, and led to his being made a member of the Royal Society, from which he received its greatest honor, the Copley Medal. He married, while at Warrington, in 1763, the daughter of Mr. Isaac Wilkinson, an iron-master. Although not settled as a clergyman at Warrington, he kept up the habit of preaching, and was here ordained. Dr. Priestley stammered so badly that he sometimes thought he must give up preaching, but he at length measurably conquered the defect by the daily habit of slow reading in a loud voice. He recognized that this defect of delivery saved him from the temptation of trying to be an orator.

In 1767, Dr. Priestley went to Leeds and took charge of a chapel, and here he engaged keenly in the study of theology, and produced a great number of controversial works. He commenced his investigations on airs, and published a history of the discoveries in relation to vision, light, and colors, as the first part of a general history of experimental philosophy, which was not continued, because it failed to pay expenses. Here, likewise, he commenced the publication of a periodical, the *Repository*, devoted to theological subjects. Among numerous other things, he wrote an "Essay on Government," an enlarged "English Grammar," a "Familiar Introduction to the Study of Electricity," a "Treatise on Perspective and Chart of History," and, at the request of Drs. Franklin and Fothergill, an "Address to Dissenters on the Subject of the Difference with America."

It was in 1769, while at Leeds, that Dr. Priestley came into conflict with Blackstone, the celebrated author of the commentaries on the laws of England. Having, in that work, approved the statutes of Edward VI. and Queen Elizabeth, denouncing the penalties of confiscation and imprisonment against all who speak in derogation of the Book of Common Prayer, and justified the continuance of these penalties, Dr. Priestley replied to him, pointing out the injustice of such statutes, and the illiberality of those who undertake to defend them. He also convicted Dr. Blackstone of inaccuracy in the statement of historical facts. To this the learned lawyer made a reply, disavowing the sentiment that "the spirit, the principles, and the practices of the sectaries, are not calculated to make men good subjects;" and generously promised to cancel the offensive paragraphs in the future editions of his work. Dr. Priestley addressed him a handsome letter, and the controversy was brought to an amicable conclusion.

It was while at Leeds, in the year 1771, that Dr. Priestley was invited by Sir Joseph Banks, who had charge of the scientific arrangements, to accompany Captain Cook's second expedition to the South Seas, in the capacity of astronomer, and accepted the invitation. He was, however, rejected by the Board of Longitude, on account of his religious opinions, which called from him the following pointed letter to Sir Joseph Banks:

"LEEDS, *December* 10, 1771.

"DEAR SIR: After the letter which I received about a fortnight ago, from Mr. Eden, who informed me that he wrote at your request, I cannot help saying that yours and his, which I have now received, appear a little extraordinary. In the former letter there was far from being the most distant hint of any objection to me provided I would consent to accompany you. You now tell me that, as the different professors of Oxford and Cambridge will have the naming of the persons, and they are all clergymen, they may possibly have some scruples on the head of religion; and that, on this account, you do not think you could get me nominated at any rate, much less on the terms that were first mentioned to me. Now, what I am, and what they are, with respect to religion, might easily have been known before the thing was proposed to me at all. Besides, I thought that this had been a business of philosophy, and not of divinity. If, however, this be the case, I shall hold the Board of Longitude in extreme contempt, and make no scruple of speaking of them accordingly, taking for granted that you have just ground for your suspicions. I most sincerely wish you a happy voyage, as I doubt not it will be greatly to the emolument of science; but I am surprised that the persons who have the chief influence in this expedition, having (according to your representation) minds so despicably illiberal, should give any countenance to so noble an undertaking. I am truly sorry that a person of your disposition should be subject to a choice restricted by such narrow considerations. I am, etc., J. PRIESTLEY."

After six years' stay at Leeds, Dr. Priestley left, and entered into a relation with Lord Shelburne, afterward Marquis of Lansdowne, the arrangement being brought about by Dr. Price. Priestley was to be librarian and companion to his lordship, with a salary of $1,250 a year, and a house, and a life-pension of $750 a year in case of separation. His family was situated near Lord Shelburne's country-seat, where he spent his summers, but a great part of the winter was passed in his lordship's house in London. Priestley traveled with Shelburne on the Continent, and spent some time in Paris, where he says he found "all the philosophical persons, to whom I was introduced at Paris, unbelievers in Christianity, and even professed atheists. As I chose on all occasions to appear as a Christian, I was told by some of them that I was the only person they had ever met with, of whose understanding they had any opinion, who professed to believe in Christianity. But, on interrogating them on the subject, I soon found that they had given no proper attention to it, and did not really know what Christianity was. This was also the case with a great part of the company that I saw at Lord Shelburne's." While in this situation, Dr. Priestley had much leisure for scientific research, and was active in prosecuting his experiments. Lord Shelburne allowed him $200 a year extra to assist in this object. This arrangement continued seven years, when his lordship seems to have got tired of it, and a separation resulted, although it was entirely amicable. Some years afterward his lordship proposed to renew the relation, but Priestley declined.

Dr. Priestley then took up his residence in Birmingham, where he assumed charge of a congregation, and continued for several years engaged in his theological and scientific investigations. His apparatus, by the liberality of his friends, had become excellent, and his income was now so good that he could prosecute his researches with freedom. He here continued his *Theological Repository*, and published a variety of tracts on his peculiar opinions in religion and upon the history of the primitive Church.

Dr. Priestley had commenced the investigation of gases while living at Leeds, and had there prepared the first volume of his researches upon air. These researches were continued during his residence with Lord Shelburne, and the last three volumes of his experiments on air were printed after he was settled in Birmingham; and while here he also contributed various papers to the Transactions of the Royal Society. No man ever entered upon any undertaking with less apparent means of success than Dr. Priestley did on the investigation of *airs*. He was unacquainted with chemistry, excepting that he had some years before attended an elementary course delivered by Mr. Turner, of Liverpool. He had no apparatus, and knew nothing of chemical experimenting, and was without means to carry on investigations. These adverse conditions may, however, have been serviceable as he entered upon a new field of chemistry, where apparatus had to be invented, and the arrangement devised by him for the manipulation of gases is unsurpassed in simplicity, and has been in use ever since. The first of his discoveries was nitrous gas, the properties of which he ascertained with much sagacity, and applied it to the analysis of air. It contributed very much to all subsequent investigations in pneumatic chemistry, and may be said to have led to our present knowledge of the constitution of the atmosphere. It was while living with Lord Shelburne that he made his grand discovery of oxygen gas, and established the properties of that remarkable body. He showed its power of supporting combustion better, and animal life longer, than the same volume of common air. Lavoisier laid claim to the discovery, but Dr. Priestley informs us that he prepared this gas in M. Lavoisier's house in Paris, and showed him the method of procuring it in the year 1774, which is a considerable time before the date assigned by Lavoisier for his pretended discovery. Scheele, however, the Swedish chemist, actually obtained this gas without any previous knowledge of what Priestley had done, but the book containing this discovery was not published till three years after Priestley's process became known to the public.

Dr. Priestley first made known sulphurous acid, fluosilicic acid, and muriatic acid, and pointed out easy methods of procuring them; he describes with exactness the most remarkable properties of each. He likewise pointed out the existence of carburetted hydrogen gas, though he made but few experiments to determine its nature. He also discovered protoxide of nitrogen, and, after he came to this country, carbonic-oxide gas. Though not strictly the discoverer of hydrogen, yet his experiments on it were highly interesting, and contributed to the progress of the science. Nitrogen had been previously discovered, but we are indebted to him for a knowledge of most of its properties. To him also we owe the knowledge of the fact that an acid is formed when the electric sparks are made to pass for some time through a given bulk of common air; a fact which led afterward to Mr. Cavendish's great discovery of the composition of nitric acid. His experiments on the influence of plants and animals upon the air were interesting and important.

It has been said of Dr. Priestley that he was fond of controversy, yet he never sought it, and, if he participated in it, it was generally because it was thrust upon him, and he became the defendant rather than the assailant. His discussions, so far as they depended upon himself, were commonly carried on without anger, and he was never malicious or even sarcastic, unless provoked. Had he been of a quarrelsome disposition, it would have been evinced in the numerous and changing relations with the people among whom he lived, but he never quitted a situation but with the sincere regrets of those among whom he had dwelt, and with parting testimonies of their affectionate approbation of his conduct. He was, however, a man of strong convictions upon subjects of the highest interest, and of great intellectual force, and, what is still more important, he represented an unpopular class and held opinions that were generally regarded in England with detestation. These facts go far to explain the controversies in which he was engaged, without attributing to him a love of disputation.

It was while in Birmingham that he was drawn into conflict with the established clergy of the place, which became embittered, and, ending in violence and persecution, darkened the close of his life. The utmost that can be said in condemnation of Priestley at this time is, that he expressed his opinions with a degree of freedom which, though it would have been of little consequence at any former period, was ill-suited to the temper of the times. We have seen that Dr. Priestley had published an essay on the first principles of civil government. In this he laid down as the foundation of his reasoning that "it must be understood, 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 the majority of the members of any state, is the great standard by which every thing relating to that state must be finally determined; and, though it may be supposed that a body of people may be bound by a voluntary resignation of all their rights to a single person, it can never be supposed that the resignation is obligatory on their posterity, because it is manifestly contrary to the good of the whole that it should be so." From this first principle he deduces all his political maxims. Kings, senators, and nobles, are merely the servants of the public; and, when they abuse their power, in the people lies the right of deposing and consequently of punishing them. He examines the expediency of hereditary sovereignty, of hereditary rank and privileges, of the duration of Parliament, and of the right of voting, with an evident tendency to democratic principles. Though he approved of a republic in the abstract, yet, considering the prejudices and habits of the people of Great Britain, he laid it down as a principle that their present form of government was best suited to them. He was an enemy to all violent reforms, and thought that the change ought to be brought about gradually and peaceably.

These principles excited no alarm and drew but little attention at the time of their publication in 1788, but the perturbation occasioned throughout Europe by the French Revolution was very conspicuous in England, and it was during the state of public irritability upon that subject that Dr. Priestley's teachings were made a source of public alarm. Opposed to a state church, liberal in religion, and advocating freedom of thought and liberty of discussion, he was represented as the enemy of the government and the foe of religion. The French recognized his eminent position as a champion of liberal thought, and he was honored by being made a citizen of France, and a member of the Assembly. This made him in a high degree obnoxious at home, and was laid hold of by his antagonists to convince the people that he was an enemy to his country, that he had abjured his rights as an Englishman, and had adopted the principles of the hereditary enemies of Great Britain. The clergy of the English Church, who began about this time to be alarmed for their establishment, of which Dr. Priestley was the open enemy, were particularly active; the press teemed with their denunciations of him, and the minds of their hearers were inflamed against him. This vicious state of feeling at length broke bounds and issued in violence. On the day of the anniversary of the French Revolution, in 1791, there was a riot in Birmingham, in which Dr. Priestley's meeting-house and dwelling-house were burned, his library and apparatus destroyed, and many manuscripts, the fruits of years of industry, were consumed in the conflagration. The houses of several of his friends shared the same fate, and his son was only saved from death by the care of a friend who concealed him for several days. Dr. Priestley was obliged to make his escape to London, and a seat was taken for him in the mail-coach under a borrowed name. Such was the ferment against him that it was believed he would not have been safe anywhere else, and his friends would not allow him for several weeks to walk through the streets. He was invited to Hackney to succeed the celebrated Unitarian clergyman Dr. Price. He accepted, but such was the dread of his unpopularity that nobody would let him have a house, from an apprehension that it would be burned by the populace. He was obliged to get a friend to take the lease for him, and it was with the utmost difficulty that he could prevail with the landlord to transfer the lease to him, as he alleged that he was not only afraid that it would be demolished, but that his own residence, twenty miles off, would go next. When he got settled, his friends living near were advised to remove their valuable effects. Servants could not be induced to stay with him, and his neighbors were in fear of damage by his presence. The members of the Royal Society, of which he was a fellow, declined admitting him to their company, and he was obliged to withdraw his name from the Society. His eldest son was in business in Manchester with a partner who, although a man of liberality himself, was so panic-struck by the state of the public mind that he dissolved the business connection. Dr. Priestley was burned in effigy with Paine, and threatened and denounced in private letters. At a dinner of the prebendaries of a cathedral church, the conversation turning on the riots in Birmingham, and on a clergyman having said that if Dr. Priestley were mounted on a pile of his publications he would set fire to them and burn him alive, they all declared that they would be ready to do the same. Dr. Priestley had been a friend of Edmund Burke, who wrote a furious book against the French. This was replied to by Priestley so ably that the orator was greatly exasperated and inveighed against his friend's character repeatedly in the House of Commons. Dr. Priestley denied his charges, and called on him for proof again and again, but he made no reply, whereupon the doctor published that Burke "had neither ability to maintain his charge nor virtue to retract it." Dr. Priestley was informed, by a person who was boarding at the same house with Burke at Margate when the riots broke out at Birmingham, "that he could not contain his joy, but, running from place to place, he expressed it in the most unequivocal manner."

The prolonged persecution to which Priestley was subjected after the riots, and the extent and virulence of the feeling against him, show that the affair was something more than the mere outbreak of the Birmingham mob, and the course taken by government sufficiently attests that the riotous populace were but the tools of their superiors. While the country in general evidently exulted in his sufferings, the representatives of the nation refused to inquire into the cause of them. The courts delayed to give him the damages to which he was entitled, and their award fell $10,000 short of his real loss. As an illustration of the spirit which ruled the dispensation of justice, it may be mentioned that the manuscript of a work on the Constitution of England, as large as "Blackstone's Commentaries," was destroyed, and Priestley's own lawyer advised him not to make a claim for it, because it would be ruled as a seditious work and aggravate his case. Accordingly, this manuscript, in the schedule of losses, was simply put down as so much paper.

To the charge that he was a promoter of sedition, Dr. Priestley replied by appealing to his entire intellectual career, into which politics had hardly entered at all, from his complete engrossment with other subjects. In relation to this he says: "As to the great odium that I have incurred, the charge of sedition, or my being an enemy to the constitution or peace of my country, is a mere pretense for it, though it has been so much urged that it is now generally believed, and all attempts to undeceive the public with respect to it avail nothing at all. The whole course of my studies from early life shows how little politics of any kind have been my object. Indeed, to have written so much as I have in theology, and to have done so much in experimental philosophy, and at the same time to have had my mind occupied, as it is supposed to have been, with factious politics, I must have had faculties more than human. Let any person only cast his eye over the long list of my publications, and he will see that they relate almost wholly to theology, philosophy, or general literature."

In regard to the religious aspect of the case, he observes: "It might have been thought that, having written so much in defense of revelation, and of Christianity in general, more, perhaps, than all the clergy of the Church of England now living, this defense of a *common cause* would have been received as some atonement for my demerits in writing against civil establishments of Christianity, and particular doctrines. But, had I been an open enemy of all religion, the animosity against me could not have been greater than it is. Neither Mr. Hume nor Mr. Gibbon was a thousandth part so obnoxious to the clergy as I am; so little respect have my enemies for Christianity itself, compared with what they have for their emoluments from it."

It was the obvious tendency, as it was the undoubted design, of the systematic persecution to which Dr. Priestley was subjected, to drive him from the country. His sons, disgusted with their father's treatment, had renounced England and gone over to France; and it was expected that Dr. Priestley would follow them. He was not at first disposed to comply with the general expectation, and stated that he should not be driven away; but upon the breaking out of the war between France and England his sons emigrated to America, and this circumstance, joined to the state of isolation in which he lived, induced Dr. Priestley after much deliberation to decide upon following them. Intolerance and bigotry were thus triumphant; and the greatest scientific discoverer of his century, whose labors will reflect imperishable glory upon England, instead of receiving the honors that were due him, was hunted out of that country and driven into exile like a common felon.

Dr. Priestley sailed from London in April, 1794, and arrived in New York in June. He was received there by various societies with distinguished consideration, and a hundred subscribers, at ten dollars each, were immediately secured for a course of lectures on Experimental Philosophy. He did not, however, give them, but shortly proceeded to Philadelphia, where he received a complimentary address from the American Philosophical Society, and was unanimously chosen as Professor of Chemistry in the university. But this he did not accept, and soon proceeded to Northumberland, a town on the Susquehanna, 132 miles northwest from Philadelphia, where his sons had settled, and which he made his permanent residence. There was at first no postal connection with the place, but a mail was soon established, running to Philadelphia twice a week. His house in Northumberland was situated in a garden commanding one of the finest prospects on the Susquehanna. A library and laboratory were built for him, which were finished in 1797, and he was able to arrange his books and renew his experiments with every possible facility.

While Dr. Priestley was received in this country by many with the honor that was due to so eminent a man and the sympathy to which his persecutions at home naturally gave rise, it was not to be expected that he would quite escape from the interference of the intolant and narrow-minded. There was, at that time, a powerful party in this country in sympathy with the English policy, and they very naturally participated in the English feeling toward Priestley. He did not choose to be naturalized, but, while advising his sons to become so, he said that, as he had been born and had lived to advanced years an Englishman, he would die one, let what might be the consequence. He did not interest himself much in American politics, but continued his congenial pursuits and studies. About the year 1799, during the Adams Administration, the friends of freedom were greatly alarmed at the promulgation of principles less liberal in many respects than were those of the British Government. Dr. Priestley, who never concealed his sentiments, was opposed to the administration and freely criticised it in private conversation. At the same time, violent attacks were made upon it by a Northumberland newspaper. But, although Dr. Priestley was not their author, and had nothing to do with them, they were charged to him, and such were the bigotry and party zeal of the period that he was represented as an enemy to the Government, and it was intimated to him from Mr. Adams himself that he had better abstain from saying any thing on politics lest he should get into difficulty. The "Alien and Sedition Law" passed under that administration was then in operation, and Dr. Priestley might have been sent out of the country at a moment's warning, without being charged with any offense and without even the right of remonstrance; and it was hinted to him that he was one of the persons contemplated when the law was passed. The epithet *alien*, which was used as a term of party reproach at that time, was freely applied to him. In consequence of all this, Dr. Priestley wrote a series of letters to the inhabitants of Northumberland, in which he expressed his sentiments fully on all political questions, and which had the effect of removing unfavorable impressions which had been made on the minds of the people.

It is important to state, in illustration of Dr. Priestley's principles and character, that he believed most thoroughly in the efficacy of private enterprise for carrying on all works of popular beneficence. A powerful opponent of state-enforced religion, he was led to go much further and to condemn government patronage in numerous other cases. And this was very far from being a matter of sour grapes, or a repudiation of advantages, because he could not himself participate in them. On the contrary, he had the most brilliant and tempting opportunities. His residence and intimacy with Lord Shelburne brought within his reach the largest prospects of political and ecclesiastical preferment, both of which he resolutely declined. Under two different administrations, overtures were made to him to accept a pension from Government; but he stands conspicuously alone in his age in resisting the temptation and preserving his independence. He, however, accepted assistance from private generosity, and was always grateful for donations from this source. As an illustration of how he continued to be appreciated in England after leaving it, it should be stated that Mrs. Elizabeth Rayner allowed him a pension of $250 a year, and in her will left him $10,000. Mr. Dodson left him $2,000; Mr. Salte, $500; and the Duke of Grafton remitted him annually $200. About the time he died, a few other friends made up $1,000 a year, which was quickly increased to $2,500, which was to have been continued during his life. These contributions were made in consideration of the heavy expense of his experimental researches, and the printing of his Church history and other theological works. These examples of generous appreciation were peculiarly grateful to Dr. Priestley, after the treatment he had received at home.

In 1801 Dr. Priestley had a severe illness in Philadelphia, and, after that, never fully recovered his strength. He was subject to attacks of inflammation of the stomach and paralysis of the throat, which prevented swallowing. In January, 1804, his complaint grew so serious that life began to be doubtful, and he used to tell the physician that, if he could but patch him up for six months longer, he should be perfectly satisfied, as by that time he could complete the printing of his works. This, however, was not granted, for he died on the 6th of February, seventy years ago, after working to almost the last hour. His old congregation, at Birmingham, erected a monument to his memory in their place of worship after his decease, and a fine marble statue has been recently put up in his honor in the University of Oxford. The accompanying engraving is from a portrait by the celebrated painter Gilbert Stuart.

It remains to add, that Dr. Priestley was eminently fortunate in his domestic relations. His wife possessed rare qualifications, as a helpmeet to her husband, and had a large share in the success of his career; for, although, as far as we can learn, she did not participate in his special studies, yet it appears that, but for her, he never could have carried through his numerous and formidable undertakings. His testimony to this is explicit. He says: "My wife was a woman of excellent understanding, much improved by reading, of great fortitude and strength of mind, of a temper in the highest degree affectionate and generous, feeling strongly for others and little for herself. Also, greatly excelling in every thing relating to household affairs, she entirely relieved me of all concern of that kind, which allowed me to give all my time to the prosecution of my studies, and the other duties of my station." His son states that his father used to say that he was merely a lodger, and had all his time to devote to his own pursuits.

All honor, then, to the wife to whose womanly devotion the world is indebted for whatever is great and good in the achievements of the husband! We have lately heard much of a great man who attributes all his profoundest thoughts to the genius of his wife, he being really only a scribe and editor; but we here see how a great man may owe his intellectual eminence to his wife, even though she be not so gifted as to be able to furnish all his best ideas. Of the two methods, this is certainly the most encouraging for woman, as it assigns the highest office to her acknowledged capacities, and precludes all question of rivalry. The united pair work in separate spheres and different ways to the same end; and the wife's affections become as indispensable to the result as the husband's intellect. Had Mrs. Priestley been animated by modern views, and essayed to carve out her own separate fortune in the field of science or theology, it is eminently probable that she would have failed to do any great thing herself, and quite certain that she would have effectually defeated her husband. This must have been the result, if what Dr. Priestley says is true, that her efficient domestic aid and her sympathetic support in his trials and sufferings were among the indispensable conditions of his own success. And thus, in the seclusion of her own family, absorbed in social cares, forgetting herself in instinctive solicitude for others, and probably with no ambition beyond, this true woman and model wife was really joint-partner with her illustrious husband in the good he accomplished, if not in the fame he won. And who shall say that hers was not, after all, the nobler and happier share of the work?

EDITOR'S TABLE.

THE CENTENNIAL ANNIVERSARY OF THE DISCOVERY OF OXYGEN.

ON the 1st of August, 1874, it will be exactly a hundred years since oxygen gas was first made known to the world. This discovery is one of the most important ever made in science, and we commemorate its centennial by doing something to make more widely known the character of the illustrious man whose name will be associated with it as long as science is cultivated or civilization continues.

A hundred years of advancing knowledge has steadily exalted the importance of Priestley's discovery. It formed a great epoch in the progress of modern chemistry, and gave a profound clew to the internal constitution of Nature. The element first revealed, examined, and described by Priestley, is the most extensive in its distribution, and the most potent in its influence, of all the material constituents of the world. We now know with some definiteness the proportions in which oxygen exists in the various parts of Nature, but the aggregates are so stupendous as utterly to baffle the imagination. It exists in the smallest proportion in the atmosphere, forming but one-fifth of its weight. As there are fifteen pounds weight of air on every square inch of the earth's surface, it follows that there are three pounds of oxygen to the same area. By a simple calculation, it therefore turns out that the amount of oxygen in the earth's atmosphere is one quintillion, one hundred and seventy-eight quadrillions, one hundred and fifty-eight trillions of tons—a quantity absolutely inconceivable by the human mind.

In the world of waters, the scale of proportions is enormously increased, as eight-ninths of the weight of this liquid consists of oxygen. The ocean is assumed to cover two-thirds of the earth's surface, and to have an average depth of two miles, which would be sufficient to cover its entire surface to the depth of one mile and one-third. This would give us twenty-seven hundred pounds of oxygen for every square inch of the earth, or an amount in the oceans equal to nine hundred atmospheres.

Chemical analysis has also shown us the proportions of oxygen in the various classes of rocks. It forms one-half the weight of silica, one-third that of alumina, and two-thirds that of lime; and, as the great bulk of the geological formations are made up of these minerals, it follows that the entire crust of the globe, so far as it has been explored, with its twenty miles' thickness of stratified rocks and its underlying granites, consists of oxygen to the extent of one-half of its weight.

If we turn now to the world of life, although the absolute magnitudes are much less, the relative proportions of oxygen are very high, and the grandeur of its operations is simply amazing. Three-fourths the weight of the entire animal world, and four-fifths the weight of the whole vegetable kingdom, consist of this element alone. Moreover, the operations of life in both branches are intimately dependent upon its activity and the rapid changes of which it is the main agent; while the vegetable kingdom is a grand laboratory, worked by the power of the solar rays to liberate oxygen from its combinations, and pour it back into the atmosphere in a free and active state. The animal kingdom, on the other hand, through all its grades, depends for its existence upon the incessant withdrawal of oxygen from the air. Each adult person consumes two pounds a day of this gas, or over seven hundred pounds a year, or some twenty-five tons in the allotted period of seventy years; and the thousand million human beings upon the earth are all busy, day and night, from birth to death, in altering the constitution of the air at the same rapid rate. And what man is doing, all the multitudinous tribes of inferior life, in the sea, on the land, and in the air, are doing also. Besides this, the great operations of combustion, fermentation, and decay, upon the globe, are carried on by the insatiable affinities of the same ubiquitous agent. It has been calculated that the oxygen required daily to maintain the course of terrestrial transformations is no less than eight thousand million pounds, or seven millions one hundred forty-two thousand eight hundred and forty-seven tons.[1] And, though this is probably an extreme under-estimate, we have seen that the stock of free oxygen in the air is so vast that it would require millions of years for this rate of consumption to make a sensible impression upon it, even if the counter-changes of the vegetable kingdom, by which the balance is constantly restored, should altogether cease.

Such is the grandeur of the part played by this wonderful element of Nature which has now been known exactly a hundred years. In his beautiful lecture which forms the opening article of our present number, Dr. Draper has vividly portrayed the office of oxygen in relation to the scheme of terrestrial life, and to this nothing needs to be added. But it is fit, on the present occasion, to give emphasis to the fact that, up to the time of Priestley, mankind were as absolutely ignorant of these things as if they had been destitute of all capacity to understand them. The human race had indeed run a vast career of intellectual activity, and had exploited numberless fields of thought with great results. Forms of religion and systems of philosophy had grown and decayed; numerous arts were perfected and forgotten; literatures were cultivated, exhausted, and passed by; empires and civilizations had flourished and faded, and for many thousands of years the world's greatest minds had been speculating, questioning, and inventing, before the man appeared who first explained the constitution of the air, and who first gave a rational answer to the question, "What is the breath of life?" At a superficial glance we should infer that there had been an enormous waste of precious intellectual force in all those historic ages over futile and worthless subjects, and that, while investigating with infinite assiduity every thing that was remote and impossible, the vital and immediate matters of daily and intimate concern had been systematically shunned as objects of study. But the intellectual evolution of man has conformed to a method, and Nature seems to have been no more economical of her mental than of her material resources. There is a prodigality in her ways which a narrow philosophy cannot comprehend. Of her profusion of flowers, but few issue in fruit; of her myriads of eggs, but few are hatched; of her numerous tribes of life appearing in the remote past, multitudes are extinct; and, of the achievements of her intellect, the great mass is lost in oblivion. But, through all her seeming waste, Nature has, nevertheless, a grand economy. She gives the widest chances, under a system which favors the best; the failures are rejected and the fittest survive. Through apparently boundless waste, with infinite deliberation, she works onward and upward to a better state of things, and in the mental world no less than in the physical, through interminable defeats and failures, and a prodigious amount of empty and fruitless effort, solid and

[1] The foregoing data are taken from Faraday's "Lectures on the Non-metallic Elements." London: Longmans, 1853.

permanent results are at last arrived at. Modern science arose from the exhaustion of previous methods of thought. The earlier philosophy speculated concerning Nature, and sought after her truths in the depths of the human mind. All that high genius and varied intellectual power could do was done, but to no purpose until the searchers for truth changed their attitude to Nature, and began to inquire of her by the simple and despised methods of experimental investigation. Dr. Priestley, first of all men, approached the problem of the constitution of the air in this spirit, and was even compelled to devise the contrivances by which gaseous bodies could be manipulated. He was on the right track, he had struck the true method, and magnificently did Nature reward his sagacity and his wisdom. Of course, for the Greeks or the Romans, or the schoolmen of the middle ages, to have discovered oxygen, would have been impossible. Only with the decline of their modes of thought could new methods arise, and only through the apprenticeship of generations in the field of physical investigation were men prepared to pass to the subtler search of the inner nature of material things. The discovery of oxygen, therefore, came in its due time in the mental unfolding of humanity; and while to Dr. Priestley undoubtedly belongs the honor of having first disclosed and identified it, others would quickly have plucked the ripened fruit if he had not; and in point of fact oxygen was independently discovered shortly after by the Swedish chemist Scheele, who also discovered chlorine in 1774.

But, if the discovery of oxygen formed a great epoch in our advancing knowledge of the constitution of Nature, its influence was no less profound upon the advance of chemical science. We are accustomed to regard chemistry as a kind of knowledge that is peculiarly modern, but it is really very old, and has had a long course of development. Liebig has stated that the completion of a science implies three stages or operations. There are—1. The ascertainment of the properties of things by observation and experiment; 2. The bringing of them into relation by principles or ideas; and, 3. The application of mathematics, or subjecting the phenomena to the test of quantitative investigation. In chemistry, the first of these stages runs back to antiquity. The ancients knew many facts and made many empirical experiments in the arts which were of a chemical nature. They knew seven metals—gold, silver, mercury, copper, iron, tin, and lead. They also knew various preparations of zinc, antimony, and arsenic, and must have had a very considerable knowledge of metallurgical processes. They had also a knowledge of glass, pottery, soap, dyes, pigments, precious stones, asphalt, alum, starch, beer, and many other substances which, if not exact, was still so positive as to guide them in the processes of manufacture. This kind of knowledge of the properties of bodies must have gradually increased, and when we come down to the time of Gheber, the Arabian, who wrote a thousand years ago, we find that this species of information had not only greatly increased, but had become more definitely chemical in character, while laboratory operations were systematically practised. Gheber, for example, knew the properties of common salt, potash, soda, saltpetre, ammonia, copperas, borax, corrosive sublimate, oxide of copper, metallic arsenic, compounds of sulphur with the metals, and the methods of preparing sulphuric and nitric acids, aqua-regia, litharge, and the operations of distillation, sublimation, smelting, and a great number of chemical processes, as they were practised down to the end of the eighteenth century. By the alchemists these facts were immensely multiplied, forming a vast body of knowledge concerning the chemical properties of substances which form the foundation of the science, and constitute Liebig's first stage in its progress.

Although the second stage—the formation of general ideas or theories—is a sequence of the first, and implies accumulated observations to be explained, yet it was begun early. The doctrine of the four primitive elements, fire, air, earth, and water, was the first chemical theory, and sufficed for many centuries. To these four elements of Aristotle, which were regarded as the four fundamental causes of the physical properties of matter, were added three new elements—mercury, sulphur, and salt—which also stood for certain properties and causes of change, rather than concrete bodies. Mercury represented volatility, and was supposed to give this property to matter; sulphur was connected with changeableness by fire, or combustibility, and salt represented fixity, like the salts found in ashes. On this view, alcohol, or aqua vitæ, was regarded as "sulphurous vegetable mercury," which only meant that it was inflammable and volatile. Hence Basil Valentine says: "When a rectified aqua vitæ is kindled, its mercury and sulphur separate; the sulphur burns quite vividly, for it is pure fire, and the delicate mercury flies into the air and returns to its original chaos."

Such rude ideas answered to begin the work of chemical theorizing, but the increase of facts at length showed that they were contradictory and absurd. About a hundred years before the time of Priestley, Beccher, a German chemist, in undertaking to correct the doctrine of salt, sulphur and mercury, struck a new conception which soon grew into a comprehensive and important chemical theory. In working with sulphur, he sagaciously detected the analogy between the formation of sulphuric acid from sulphur and the reduction of metals to an earthy form (calx). The metal was supposed to consist of an earth, and something which, in the process of combustion, was separated from it; in like manner sulphur was supposed to consist of an acid and something that was separated from it, by burning, and to this something Stahl afterward gave the name of *phlogiston*—Greek for *combustible.* So intimately and extensively were fire and combustion involved with chemical changes, that a theory of combustion was regarded as the same thing as a theory of chemistry. It was assumed that all combustible bodies are compounds. One of the constituents was supposed to be dissipated during the process, while the other remained behind. The part dissipated, phlogiston, was held to be the same in all combustible bodies whatever, and hence the differences among them depended upon the residues. On this view, the property of combustibility is always owing to the presence of phlogiston, and fire, or inflammation, to its escape. Phlogiston was communicable from body to body. When phosphorus is burned it loses its phlogiston, and an acid remains. But if now the acid is heated in a retort with charcoal-powder, sugar, or resin, these combustibles are deprived of their phlogiston, which, passing over to the acid, reproduces phosphorus. Bodies saturated with phlogiston were said to be *phlogisticated*, and, when deprived of it, were *dephlogisticated*, processes which might be as partial or complete as the variations of combustive phenomena. These ideas were founded upon experiments so decisive that, when the existence of the principle itself was once admitted, the explanation was entirely satisfactory. "There are ideas," says Liebig, "so great and vast that, even when entirely perforated, as it were, in all directions, they leave enough of matter to occupy the powers of thought of mankind for a century. Such a vast idea was that of phlogiston. The question as to its material existence was void of all significance, so long as the idea was fruitful in the classification of known facts, and prepared the way for new generalizations."

Chemistry had made rapid advances under the phlogistic theory for a century, but the idea was now to be brought to the test of quantitative examination. The introduction of the balance threw a new light upon the subject, and, under its application, the assumptions of the phlogistic system of chemistry proved to be entirely erroneous. The effect of careful weighing was to show that metals and other combustible bodies, in burning, grew heavier; that there was no subtraction or loss of any thing, but always an addition; and that the compounds produced were, in every case, equal in weight to the combining elements.

Dr. Priestley was a firm believer in phlogiston, and named the new element of the atmosphere which he had discovered, dephlogisticated air. He made but little use of weighing in his researches, and was not qualified by his training to go on and reap the full scientific advantages to which his great discovery opened the way. These were secured by the French chemist Lavoisier, who named the new element oxygen, and, having by his experiments overthrown the old view, he had the largest share in establishing the oxygen theory of chemistry which took its place. As Dr. Whewell observes; "Few revolutions in science have immediately excited so much general notice as the introduction of the theory of oxygen. The simplicity and symmetry of the modes of combination which it assumed, and, above all, the construction and universal adoption of a nomenclature which applied to all substances, and which seemed to reveal their inmost constitution by their name, naturally gave it an almost irresistible sway over men's minds."

But, while the theory of oxygen has guided the development of chemistry for the past hundred years, it is now following the fate of its predecessor: the facts have outgrown it, and a "New Chemistry" has arisen in its place. Yet, whatever may be the vicissitudes of theory, oxygen is still in the field—still the object of wonderful interest, and no possible changes in the future can ever dim the lustre of its discovery.

CHARACTER OF DR. PRIESTLEY.

Several of the most distinguished chemists of the country have united in a call to all interested to convene at Northumberland, Pa., on the 1st of August, where Dr. Priestley lies entombed, to celebrate the one hundredth anniversary of his discovery of oxygen gas. Such a tribute will be most proper and befitting to his memory, and will suggest interesting phases of thought that cannot fail to make the occasion profitable to all who participate in it. In the circular of invitation it is said: "The fact that this illustrious man spent the last years of his fruitful life in this country, renders the recognition of his work by American chemists peculiarly appropriate;" and it may be added that the circumstances which brought him here, and which pertain both to his own character and the condition of his native country, are matters especially suitable for consideration at such a time. For Dr. Priestley was more than an eminent scientific discoverer — he was a sincere, courageous, high-minded man, and stood forth as the unflinching champion of liberal opinion when his country was given over to the narrow spirit of fanatical bigotry. Dr. Priestley's career exhibits the sublime moral spectacle of a man against a nation, and that, too, on a vital question of constitutional rights; and such was the conduct of the two parties, as, in the language of Dr. Thomson, to "fix an indelible disgrace upon the country," while Dr. Priestley's course will be honored as long as freedom of opinion and independence of character elicit the admiration of men.

Dr. Priestley's intellectual greatness is the more remarkable as he led what may be called a divided life. He was a discoverer in science, and a pioneer in theology. His extensions of our knowledge of Nature will suffice for his immortality, while the extent and power of his theological work made him famous among his contemporaries. Nevertheless it is only by concentration that the highest results can be achieved. We have shown in the preceding article where Dr. Priestley fell short as a man of science. His scientific education was insufficient. He began these studies late, and pursued them at great disadvantage, for scientific pursuits are expensive. He says: "I applied myself with great assiduity to my studies, which were classical, mathematical, and theological. These required but few books. As to experimental philosophy, I had always cultivated an acquaintance with it, but I had not the means of prosecuting it." His great rival, Lavoisier, was more fortunate. His father was rich, and spared no expense on his education; and, having an early taste for the physical sciences, he was trained to experimental research, which he pursued so successfully that, at twenty-one, he received a gold medal for a memoir on the best and most economical method of lighting the streets of a large city. Could Priestley have had similar early advantages, there is little doubt that he would have devoted himself entirely to science, and, with his remarkable genius for investigation, would have impressed himself far more profoundly upon the chemistry of his period.

Of the truth or error of Dr. Priestley's religious opinions, it is no place here to speak; but, that he sought the truth in all earnestness, and maintained what he believed to be the truth with steadfast determination, does not now admit of question. That he led a life of the highest purity was never doubted, even by his enemies, and that he was ever animated by a high religious aspiration his works bear abundant witness. A portion of each day was given to prayer and private devotional exercises, and he kept up the practice of Sunday preaching, whether officially engaged or not; while the uniform testimony of all his parishioners showed that his ministrations were conducted in a loving, Christian spirit. Shall we question that the religious experience of such a man was not profound and genuine? And yet he was a speculative materialist; that is, he did not believe in "the immateriality of the sentient principle in man." No one, however, had a firmer belief in immortality and the future life than Dr. Priestley. This transcendent article of his faith he did not ask at the hands of Science nor hold as dependent upon her investigations. His repose in the prospect of immortality was grounded on the Christian doctrine of a resurrection; no results of science could reach or disturb it, and in this he was far in advance, not only of his own age, but of ours. As an illustration of his independence of character, and his scorn of all temporizing, it may be stated that he promulgated these views while living under the patronage of Lord Shelburne, and beset with solicitations to accept high favors from the Church and the state. Undoubtedly, as Dr. Draper remarks, it is upon his discoveries that his future fame will rest, while his theological works are already forgotten; yet the world owes him a debt for his manly maintenance of independent inquiry in a cowardly age and among a craven people, which will command respect as long as the nobler virtues of character continue to be appreciated.

SCIENTIFIC APPARATUS.

The attention of those desiring to procure physical-science apparatus is called to the advertisement of Professor W. C. Richards, Ph. D., who, having retired from the public lecture-field, offers for sale his extensive collection of instruments. The stock includes duplicates of important pieces, such as coils, batteries, spectroscopes, vacuum-tubes; and it offers an excellent chance for colleges, high-schools, and private students, to supply themselves from this collection. Those who are in want of such instruments should send to Professor Richards for his catalogue.

LITERARY NOTICES.

Smithsonian Miscellaneous Collections; The Constants of Nature. Part 1. Specific Gravities; Boiling and Melting Points; and Chemical Formula. Compiled by Frank Wigglesworth Clarke, S. B. Washington, D. C., 1873.

This volume of 263 pages is No. 255 of the publications of the Smithsonian Institution, and it is yet another evidence of the care and thought bestowed by the venerable Secretary of that Institution upon all means and aids suitable for the advancement of human knowledge.

It is Part I. of a series which is to contain the Constants of Nature, tabulated in such a way as to be immediately available for the uses of scientific men, as well as for general reference.

A careful examination of its general plan shows that this work has been admirably done by Prof. Clarke (now of Howard University, Washington). The work can be consulted with great convenience by means of the very complete Index, and on turning to any page the information is found in five columns side by side. The first column contains the name of the substance, as, for example, *Iodine;* in this column also the letter *l* or *s* shows that the substance has been examined in a *liquid* or a *solid* state.

The third column contains the specific-gravity determinations which have been made, accompanied by figures showing the temperature at which they were made, and a reference number to each line indicates the authority (volume and page usually) from which the datum is selected. Another symbol in this column, "*m.* of 6," for example, shows that the determination was the *mean of six* determinations.

The next column gives the boiling-point in degrees Fahrenheit, together with the height of the barometer at which this element was determined, and the fifth column gives the melting-point.

Sulphur has thirty-two lines devoted to its properties; *Tin* has eighteen; *Bismuth* eighteen, etc.

As an example, we extract line No. 7 of *Sulphuric Acid.* The No. 7 refers us to a paper by H. L. Buff in the "Annals of Chemistry and Pharmacy," fourth supplement (1865–'66), p. 129, and also to various articles quoted in that paper. The line reads: "Sulphuric Acid; SO 3; 1.81958, 47°; 46° to 47° 760 m.m.; rs. 25°;" which shows that the specific gravity was determined at 47° Fahr. to be 1.81958, that at 760 m.m., the boiling-point was from 46° to 47° Fahr., and that this specimen re-solidified at 25° Fahr.

It only remains to add from Prof. Clarke's modest preface, that the work, "exclusive of its supplement, contains the specific gravities of 2,263 substances, and over 5,000 determinations in all. There are over 2,000 determinations of boiling-point, representing 1,205 different substances; and nearly 500 of melting-point for 326 different substances. In all, the names of 2,572 distinct bodies will be found in the table."

Physiology for Practical Use. Edited by James Hinton. With Introduction by E. L. Youmans. New York: D. Appleton & Co., pp. 507. Price $2.25.

Too few books have honest titles, for these are as often chosen to mislead as to instruct. The present is among those that are accurately described by their names. For, while there is a great deal of interesting scientific physiology in this volume, its distinctive character is that it furnishes physiological knowledge that can be continually applied to practical use. Dr. Hinton, the editor, is an eminent aural surgeon of London, and contributes the article to this volume on "The Faculty of Hearing." We published a portion of that article some time ago in the Monthly, and all who read it will attest that it was one of the best practical presentations of the subject that has yet appeared. The other chapters of the volume are contributed by other medical men, who have given special attention to different departments of practical physiology; and the ruling idea of all the articles is to give in the clearest and plainest manner that information concerning the bodily organs and their management which is most constantly needed, and which all common readers can understand and apply. The papers of the volume were first contributed to the *People's Magazine* in monthly parts, running through two or three years; they were then collected and carefully revised by Dr. Hinton, and brought into the unity and completeness which they now present, in the volume form.

In several respects this book presents universal claims upon the reading public. To begin with, the style in which it is written is remarkable for its simplicity, its freedom from technical terms, and its extreme *readableness.* The writers seem to have constantly kept in mind that they were addressing the non-scientific public, and they have studiously refrained from any pedantic show of physiological language. There is not a chapter in the volume that any ordinary person cannot take up and peruse with facility and pleasure. The importance of this cannot be over-estimated where the object is to produce clear and lasting impressions upon the general mind.

In the next place, the selection of the subjects treated is as practical as the manner of their statement. How completely the whole ground is covered may be shown in no other way so well as by an enumeration of the subjects, which are as follows:

I. The Brain and its Servants.
II. The Faculty of Hearing.
III. The Eye and Sight.
IV. The Sense of Smell.
V. The Sense of Taste.
VI. Digestion.
VII. The Skin.—Corpulence.
VIII. The Bath.—The Sense of Touch.
IX. Notes on Pain.
X. Respiration.
XI. Taking Cold.
XII. Influenza.
XIII. Headache.
XIV. Sleep.
XV. Sleeplessness.
XVI. Ventilation.
XVII. The Liver and its Diseases.
XVIII. The Action of Alcohol.
XIX. Muscular Motion as exemplified in the Human Body.
XX. Occupation and Health.
XXI. Training and Gymnastics.

In the third place, on all of these subjects it has been the aim of the writers to present that kind of information which can be made practically available for the preservation of health. There is only so much scientific physiology as is calculated to give point and effect to the useful inculcations of the work. It is the best popular hygienic treatise that we know, and is the kind of book to tell in a salutary way upon the daily conduct. It is here that our physiological text-books generally break down. The information they contain is of the wrong kind—too scientific and too unpractical. There is a good deal of excellent science in this volume, clear and accurate in its presentation; but it is all subordinated to the useful lessons and conclusions that are enforced in regard to what may be called physiological conduct and practice. Such a volume has been long wanted, and we commend it for family reading and for class-exercises in schools, as superior to any other we know.

The American Annual Cyclopædia and Register of Important Events of the Year 1873. Embracing Political, Civil, Military, and Social Affairs; Public Documents; Biography, Statistics, Commerce, Finance, Literature, Science, Agriculture, and Mechanical Industry. Volume XIII. New York: D. Appleton & Co., 1874, pp. 805. Price, $5.00.

This work, which is extended to thirteen volumes, forms the completest history of contemporaneous events that is now to be obtained. Year-books of science, agriculture, inventions, and arts, have latterly appeared, in response to the demand for the results of the annual progress in these departments. But something more comprehensive was needed, that should treat of what is done in all the great branches of activity. Appletons' Annual Cyclopædla is perhaps the most perfect register of the advance of civilization that we have—covering the complete ground, carefully compiled, conveniently arranged for consultation, and constituting a full repertory of passing occurrences. It is indispensable to the student of current affairs, and should have a place in the library of every working thinker. Appletons' Annual Cyclopædia is a work entirely distinct from their regular American Cyclopædia, which is of a more general character, and treats of the past as well as of the present.

The volume just issued contains the annals of the past year. Its wars and military operations are faithfully described. The internal commotions of states also receive due attention, and the student of foreign politics will peruse, with keen interest, the succinct account here given of the civic strifes of France and Germany, and the sanguinary conflict still going on in Spain. The chronicle of home events is very full. The questions which occupied the minds of our legislators during the year, and which have in any way affected the prosperity of the country, are faithfully presented. Thus we have articles on the national finances, revenue, and taxation; banking, financial crises, commerce, manufactures, etc. The financial condition of the several States also receives attention. In short, no great public concernment is overlooked, and, to give an exact idea of what this volume contains, we should have to enumerate every living practical interest of our people—the movements of political parties, the transportation question, the granger question, the results of elections, proceedings of legislative bodies, judicial decisions, the progress of educational and charitable institutions, the extension of railroads and telegraphs, etc. The diplomatic correspondence of the United States Government, derived from authentic sources, is presented with great fullness. The progress of science, in various branches, is recorded; special prominence being given to the practical applications of scientific discoveries, and, finally, we have the authentic statistics of religious denominations in the United States.

Smithsonian Report for 1872.—The Smithsonian Institution closed the first quarter of a century of its existence with the year for which this report was made. During that time it has made itself known in every part of the civilized world, and "the publications which result from the facilities it has afforded to original research are to be found in all the principal libraries, and its specimens in all the great public museums in the world."

The report of the Secretary, Prof. Henry, evidences admirable management in the financial affairs of the Institution. The original fund, instead of being impaired, has been increased. It now amounts to $704,811; the income from which, during the year 1872, amounted to $46,916. The expenditures for the same time were $45,420. However, this good management has not always existed. Prof. Henry shows that in the establishment of the Institution, the United States Government, through a misconception of the object of the founder, expended $600,000 in the erection of buildings, while the object could have been attained by an outlay for the same purpose of only $50,000. The object of the founder appears to have been the establishment of an institution for the promotion of original scientific research, and the distribution of the knowledge thereby gained; while the Government construed it to be the establishment of a museum, library, art-gallery, lectorium, arboretum, etc. Prof. Henry now suggests that the Government should devote the present building to the use of the National Museum, and repay the Smithsonian fund $300,000; one-third of which could be used for the erection of another building suitable to the Institution, and the remainder be added to the present fund.

The most important work of the Institution consists in the publication of contributions to knowledge, or scientific papers, containing positive additions to knowledge, papers which are the results of investigations directly or indirectly fostered by the Institution, or of individual investigations, but are too expensive in character to be otherwise published. Also, the publication of miscellaneous collections intended to facilitate the study of particular branches of science. These publications are distributed with various specimens, ethnological and otherwise, to libraries and museums throughout this and foreign countries. The most important works published or prepared for publication by the Institution, in 1872, were "Tables and Results of Precipitation of

Rain and Snow in the United States and Adjacent Parts of North, Central, and South America;" "Work on the *Fresh-Water Algæ*," by Dr. Horatio C. Wood, of Philadelphia; and Prof. Newcombe's "Investigations into the Orbit of Uranus." The Institution has also in preparation "Vocabularies of the Indian Languages of North America;" a "Hypsometrical Map of North America;" and the "Meteorological Observations" of the Institution up to 1870.

The report also contains the late Prof. Agassiz's "Narrative of his Expedition from Boston through the Straits of Magellan to San Francisco," and a number of valuable papers by foreign authorities on various scientific subjects, published because of their inaccessibility to students generally.

The Construction of Mill-Dams. Springfield, Ohio: James Leffel & Co. 312 pp., 8vo. Price, $2.50.

This is a republication in book-form of a series of articles first published in Leffel's *Milling and Mechanical News*. It advances no new theory on the subject, but presents a description of various plans that have been tried and found effective in different localities. The work is more descriptive than scientific in character, but it contains some apparently valuable suggestions on the building of small and economical dams, such as are required for a single grain or lumber mill. Descriptions are given of the Housatonic Dam, in Connecticut, the Moline Dam, on the Mississippi, and other remarkable dams. A simple and seemingly sufficient method is given for determining the available power of small streams. The work is admirably illustrated throughout.

Theory of the Glaciers of Savoy. By M. Le Chanoine Rendu. Translated by Alfred Wills. With Additions by Tait, Ruskin, and Forbes. London: Macmillan, 1874. Price, $3.00.

This is a work of some historic interest, being one of the earliest contributions to the elucidation of glacial phenomena. The merit of Rendu, as a pioneer explorer in this field, is now generally recognized; and whatever of truth there was in his views has been absorbed into the common literature of the subject. Nevertheless, it is well to have his valuable book in an accessible form. But we are afraid that its intrinsic interest would have been insufficient to secure its translation, and that the reason of its appearance at the present time is to be sought elsewhere. The train of names upon the title-page gives a clew to the purpose for which it is now reproduced. A clique of Scotchmen, in getting up a biography of Principal Forbes, has contrived to get into a quarrel with Tyndall, in regard to the allotment of the honors of discovery, and Rendu's book is now used as a means of bespattering the Royal Institution professor. We publish Prof. Tyndall's review of the work, and readers who wish to go deeper into the matter can consult the book itself.

Bulletin of the Buffalo Society of Natural Sciences.

The last number of the *Bulletin* is full of interesting matter. It contains, besides other entomological contributions, several papers on the study of butterflies, by A. K. Grote, Samuel H. Scudder, and others. In "Contributions to the Geology and Physical Geography of the Lower Amazons," Prof. C. Frederick Hartt gives some valuable information on the topographical features, drainage, and geological formation of the Ereré-Monte-Alegre district of South America. The number is embellished with numerous fine plates.

Anatomy of the Invertebrata. By C. T. H. v. Siebold. Translated from the German, with Additions and Notes, by Waldo I. Burnett, M. D. Boston: James Campbell, 1874. 8vo, pp. 470. Price, $5.00.

This work was first published in 1848, and, five years later, was rendered into English, with notes and additions, by an American translator. Since its appearance, the subject of which it treats has been rapidly advanced, twenty-five years of observation and active work having added hosts of new facts, and, in many instances, totally changed the interpretation of old ones. Yet the work is now reissued in its old form, without so much as a recognition of later investigations, or of the changes that have taken place in methods of classification. The book is also defective in the total absence of illustrations, which are indispensable to the elucidation of this class of subjects. The publisher assigns, as a reason for its reappearance, that no other work on the subject meets existing requirements. This is a mistake. Both Owen and Huxley are equally eminent authorities in this field, and both have published books on the subject since Siebold—that of Huxley being later by sixteen years.

Free-Hand Drawing. By an Art-Student, author of "Ornamental and Figure Drawing." New York: D. Van Nostrand. 18mo, 85 pp. Price, 50 cents.

This book is an explanation of the primary principles of drawing. It teaches the student to draw straight and curved lines, to mingle them with effect in shading, and to realize the results of varying the direction lines in perspective. It also gives him some hints on studying from Nature, and is, in every thing, clear, simple, and effective. It is illustrated throughout.

PUBLICATIONS RECEIVED.

Half-Hours with Insects—Part III. By A. S. Packard, Jr. Boston: Estes & Lauriat. 31 pp. Price, 25 cents.

Coal, as a Reservoir of Power, by Robert Hunt, F. R. S.; and Atoms, by Prof. Clifford, M. A. No. 2, Half-Hour Recreations in Popular Science. Boston: Estes & Lauriat. 39 pp. Price, 25 cents.

The Conditions of the Conflict. Oration before the Medical Society of Kings County, N. Y. By Alexander Hutchins, M. D. New York: George F. Nesbitt & Co. 32 pp.

Kindergarten Toys, and how to use them. By Heinrich Hoffman. New York: E. Steiger, 1874. 33 pp. Price, 20 cents.

History of the Colored Schools of Nashville, Tenn. Compiled by G. W. Hubbard. Nashville: Wheeler, Marshall & Prince. 34 pp.

On the Modern Hypotheses of Atomic Matter and Luminiferous Ether. By Henry Deacon. London, 1874. 16 pp.

Longevity, or the Relative Viability of the Sexes, etc. By John Stockton-Hough, M. D. Reprinted from the *Medical Record* of June 16 and July 15, 1873. 9 pp.

Annual Report of the Supervising Surgeon of the Marine Hospital Service of the United States. From July 1, 1872, to June 30, 1873. By John M. Woodworth, M. D. Washington, 1873. 8vo, 154 pp.

Observations on the Pathology and Treatment of Cholera. By John Murray, M. D. New York: G. P. Putnam's Sons. 12mo, 58 pp. Price, $1.00.

On the Thermal and Mechanical Properties of Air, and other Permanent Gas, subjected to Compression or Expansion. By Prof. R. H. Thurston. Philadelphia, 1874. 7 pp.

An Extract from the First Volume of the Final Report upon the Geology of New Hampshire. By C. H. Hitchcock. Concord, 1874. 53 pp.

Report of the Civil Service Commission to the President, April 15, 1874. Washington. 98 pp.

A New System of Plane Trigonometry. By Marcius Willson. New York, 1874.

The Philosophy of Evolution, together with a Preliminary Essay on the Metaphysical Basis of Science. By Stephen H. Carpenter, LL. D. Madison, Wis., 1874. 32 pp.

Catalogue of Flowering Plants of the Southern Peninsula of Michigan. By N. Colman. Grand Rapids, 1873. 49 pp.

Report of the Board of Commissioners of the Fourth Cincinnati Industrial Exposition, 1873. 267 pp.

On Geographical Variation in Color among North American Squirrels. By J. A. Allen. Boston, 1874. 21 pp.

Annotated List of the Birds of Utah. By H. W. Henshaw. Salem, 1874. 14 pp.

Proceedings of the Ninth Annual Meeting of the New England Cotton Manufacturers' Association. Boston: L. F. Lawrence & Co., 1874. 29 pp.

Metamorphism produced by the Burning of Lignite Beds in Dakota and Montana. By J. A. Allen. Boston, 1874. 19 pp.

Ancient Faiths embodied in Ancient Names, or an Attempt to trace the Religious Belief, Sacred Rites, and Holy Emblems of Certain Nations. By Thomas Inman, M. D., London. New York: Asa K.

Butts & Co., 1874. 2 vols., 8vo, 1820 pp. Price, $27.00.

Descriptions of New North American Phalænidæ and Phyllopoda. By A. S. Packard, Jr. Salem, Mass., 1874. 18 pp.

Essays and Addresses by Professors and Lecturers of the Owens College, Manchester. London: Macmillan & Co., 1874. 8vo, 560 pp. Price, $5.00.

MISCELLANY.

The Priestley Celebration at Northumberland.—The proposition for a Chemical Centennial, alluded to in the June number of the Monthly, has taken practical shape, and is to be carried out by a meeting or celebration at Northumberland, Pa., beginning on the 31st of July, 1874. A large number of the eminent chemists of the country have united in an invitation to their brethren to participate in the exercises of the occasion, in the belief that it will foster a feeling of fraternity, and afford a fitting opportunity for that interchange of ideas so important to the advancement of science. Prof. H. Carrington Bolton, of the Columbia College School of Mines, is chairman of the general committee having the matter in charge, and any information respecting the arrangements for the meeting may be obtained by addressing him. In a circular issued by this committee, those planning to attend the meeting at Northumberland are requested to send their names to Dr. Robert McCay, of that place, secretary of the *local* committee of which Dr. Joseph Priestley is chairman.

In order to add to the interest of the occasion, a Loan-Exhibition will take place during the meeting, for displaying apparatus, books, manuscripts, etc., etc., belonging to Dr. Priestley, or other objects illustrating the history of chemistry. Gentlemen interested are earnestly requested to contribute any thing in their possession appropriate to this exhibition. It is expected that the exercises will include an address by Prof. Joseph Henry; a sketch of the life and labors of Priestley, by Prof. Henry H. Croft; a review of the century's progress in theoretical chemistry, by Prof. T. Sterry Hunt; a review of the century's progress in industrial chemistry, by Prof. J. Lawrence Smith; and an essay on American contributions to chemistry, by Prof. Benjamin Silliman. Detailed programmes of the exercises will be distributed at the meeting.

Belt's Theory of Cyclones.—In the "Naturalist in Nicaragua," Mr. Belt has the following on the origin of whirlwinds and cyclones: "I am confident that a study of the smaller eddies of air is the proper way to approach the difficult question of the origin of cyclones." The movements of these small whirling masses may be observed from the outside, and their progress traced from the incipient stage to that of dissolution. In the beginning of a whirlwind there is a movement near the surface of the ground of light particles of dust toward a centre, attended or occasioned by a rotary motion of the air. This quickly rises into a whirling column from fifty to a hundred feet or more in height. On the dry hot plains of Central and South America, and of Australia, this phenomenon is of frequent occurrence, and is not unusual in our temperate latitudes in summer. The whirling columns, according to Mr. Belt, differ in diameter from a few feet to many miles, and his opinion is that "there is a complete gradation from the little dust-eddies, through larger whirlwinds and tornadoes, to the awful typhoons and cyclones of China and the West Indies."

In the small whirlwinds which occur over the land, there is no evidence of the condensation of vapor occurring in dry air. But, where the atmosphere is charged with humidity, as over tropical seas, the condensation is great. The notion, therefore, that whirlwinds and tornadoes originate in sudden condensation, Mr. Belt thinks not well founded, the phenomenon being an incident rather than a cause of the movement. Nor is the theory a satisfactory one, that the meeting of conflicting currents of air and consequent condensation give rise to the phenomenon. Attention is directed to the fact that many terrible whirlwinds are dry, and run their course without producing rain or cloud. They originate at or very near the surface of the ground, where the air becomes intensely heated. "The quivering of the air over hot ground foreshadows the whirlwind as mirage does the simoom, and sultry heat and oppressive calm do the hurricane." In the stratum of heated air next the ground resides the energy which produces the whirlwind. That this, in many instances, is prevented from rising, has been proved by numerous observations. At last the upward tendency becomes so strong that it breaks through the overlying heavier air, and there occurs an upward discharge, followed by all the phenomena of whirlwinds.

Dupuy on the Functions of the Brain.—Dr. Eugène Dupuy, of Paris, has repeated Ferrier's experiments on the brain, with results which do not accord with those of the English physiologist. In the MONTHLY for December last we gave an account of Ferrier's researches, and hence it will suffice to say here that in his experiments stimulation of the superior external convolution of the brain produced movement of the animal's paw; of the mid-frontal region, contraction of the eyelid; of the parietal region, movement of the ear; of the lower frontal and orbital regions, movement of the tongue. He therefore concludes that in these regions there are actual centres for the movements obtained. Dupuy, on the other hand, wherever the electrodes were placed, whether on the frontal, parietal, or orbital convolutions, succeeded only in obtaining, on slight stimulation, movements of the opposite fore-paw, which, on stronger stimulation, extended to the whole of that side of the body. Further, the electrodes applied to the uninjured surface of the dura mater over the convolutions produced the same effect as when placed on the exposed convolutions themselves.

Dupuy was led to suspect that the electrical stimulation might in these cases be so diffused through the whole hemisphere as to affect directly the base of the brain or even the nerves arising there. To ascertain the truth of this matter he laid bare one-half of the brain of a dog, under complete anæsthesia, and applied to the posterior extremity of the hemisphere the nerve of a galvanoscopic frog, duly insulated. The electrodes were then placed on the front of the hemisphere, and movements produced in the opposite fore-paw, the legs of the frog being simultaneously thrown into violent contraction. Upon another dog, under partial anæsthesia, he divided the corpus striatum and optic thalamus on one side, the corpus callosum having previously been cut through. The electrodes were then placed on the convolutions above and behind the Sylvian fissure. With a strong current, not only the fore-leg of the opposite side, but also the hind-leg, exhibited contraction. In another experiment he removed the whole cerebral mass above the pons Varolii, and applied the electrodes to the cut surface; muscular contractions resulted, limited to the fore-limbs, right and left. These results, many times obtained, render it certain, according to Dr. Dupuy, that electrical stimulation, to whatever part of the brain it may be applied, is widely diffused; and that such diffused stimulation, reaching the base, and there affecting the nuclei, the medulla, or the nerves themselves, will explain all the phenomena obtained by Ferrier and by himself on faradizing the convolutions.

The Sponge-Fisheries.—The chief industry of the Sporades Islands, in the Grecian Archipelago, is the sponge-fishery. The yearly average crop of sponges is estimated at £120,000 sterling. The diving-apparatuses used in the fishery are imported exclusively from England and France. Though there is no difference in construction between English and French machines, with regard to the depth they can attain, or the length of time a diver can remain under water, still English apparatus generally proves stronger, and the gears are of superior quality. The air-tubes, however, have hitherto labored under the disadvantage of being heavier than the French, thus impeding the free movements of the diver, the tubes being caught among the rocks. But, samples of French floating tubes having been sent to England, the result has already been a great improvement in the manufacture of the English article. A common fraud practised by traders in rough sponges is to introduce into them a quantity of sand, so as to add to their weight. In order to guard against this, agents are now sent to Rhodes, which is the centre of this commerce, to purchase the sponge from the divers or owners of diving-apparatus. In this way the article may be got at first hand, without being weighted with sand.

Alligators swallowing their Young.—Colonel Caleb G. Forshey, of the New Orleans Academy of Science, *à propos* of the question whether snakes swallow their young, states that this habit is certainly found among alligators. "That alligators swallow their young," says Prof. Forshey, "I have had ocular demonstration in a single case; and have the universal tradition of negroes and whites in this region of Louisiana, Mississippi, and Texas, that such is their habit. In the winter of 1843–'44, I was engaged making a survey on the banks of the Homochitto Lake. The day was warm and sunny, and, as I halted near the margin of a pond partly dried up, to pick up some shells, I started a litter of young alligators, that scampered off, yelping like puppies, and retreating some twenty yards to the bank of Lake Homochitto. I saw them reach their refuge in the mouth of a five-foot alligator. She evidently held open her mouth to receive them, as, in single file, they passed in beyond my observation. The dam then turned slowly round, and slid down beneath the water, passing into a large opening in the bank, beneath the root of an ash-tree. Doubtless this refuge is temporary, and the young are released at their own or the mother's pleasure."

Le Conte on the Origin of Western Mounds.—Prof. Joseph Le Conte, in the *American Journal of Science*, discusses the origin of the *mounds* with which the prairies near Puget Sound are studded, and from which they get the name of "mound prairies." These mounds are generally three or four feet high, and thirty to forty feet in diameter at the base. There are millions of them, and they stand so thickly as to touch each other at their bases, leaving no level space between. They consist wholly of a drift-soil of earth, gravel, and small pebbles, the intervals being thickly strewed with larger pebbles and small bowlders. The vegetation of the mounds is mostly ferns; the intervals are covered with fine grass only. Some have supposed that they are Indian burial-mounds; others have thought that they are artificial mounds, upon which were built huts of Indian villages. They have also been supposed to be large fish-nests, dating from the period when these prairies were the bottoms of shallow inlets of the sea. The author holds them to be the result of surface-erosion under peculiar conditions. In another part of the State, viz., between the Dalles and the upper bridge of the Des Chutes River, a distance of about thirty miles, the whole country is literally covered with mounds of this kind. Here they vary in *size*, from scarcely detectible elevations, to mounds five feet high and forty in diameter at the base; and in *form* from circular, through elliptic and long elliptic, to ordinary hill-side erosion-furrows and ridges. In *regularity* of size and position there is equal diversity; in some places being as complete as at Mound Prairie, while, in other places, they are of different sizes, and often separated by *wide, pebble-covered spaces*, as if they were but the remnants of a general erosion of the surface-soil. No one, says Prof. Le Conte, can ride over those thirty miles, and observe closely, without being convinced that these mounds are wholly the result of surface-erosion, acting under peculiar conditions. These conditions are, a *treeless country*, and a *drift-soil*, consisting of two layers—a finer and more movable one above, and a coarser and less movable one below. Surface-erosion cuts through the finer superficial layer, into the pebble-layer beneath, leaving, however, portions of the superficial layer as mounds. The *size* of the mounds depends on the *thickness* of the superficial layer; their *shape* depends much on the *slope* of the surface. The process once started, small shrubs and weeds take possession of the mounds, as the better soil, and hold them by their roots, and thus increase their size, by preventing or retarding erosion. The treelessness of Eastern Oregon has been produced gradually, since post-tertiary times, by the increasing dryness of the climate. We may imagine the mounds, therefore, as having been *held by the struggling remnants of a departing vegetation.* At Mound Prairie, however, the treelessness is probably produced by a contrary condition, viz., the extreme *wetness* of these lower level spots in winter.

Here, therefore, the weeds and ferns hold and preserve the mounds, not only as the better soil, but also as the drier spots.

The Value of Vivisections.—Prof. M. Schiff, of Florence, whose vivisections gave rise to the recent controversy on the cruelty of the practice, has published a book, in which he states the results of his experiments. The following quotations from this work will best show whether, as the opponents of vivisection have claimed, experiments of this kind "lead to no useful result," or are to be classed as "acts of needless cruelty." Prof. Schiff has studied the comparative effects of ether and chloroform on the animal economy. Ether, according to him, is preferable to chloroform as an anæsthetic, because etherization, even when pushed to the very last stage of insensibility, is never dangerous to life, so long as one maintains the act of respiration. And even if one presses the inhalation of ether still further, so that the respiratory movements cease, life is never menaced, if, at the moment of the paralysis of the thoracic walls, artificial respiration is immediately commenced. Chloroform has been preferred to ether because it acts more quickly, and its use is more agreeable to some persons. But chloroform has a paralyzing action much greater than that of ether, and, in like manner, has a special influence on the nerves of the heart, and of the vessels. If the inhalation of chloroform is carried so far as to produce a considerable weakening of the respiratory movements, the interruption of the inhalation may, in a majority of cases, lead to the reëstablishment of respiration, and, afterward, of sensation; but sometimes, in a few moments after the commencement of inhalation, the force of the circulation is so enfeebled that the blood passes sluggishly through the lungs, and its rate of renewal or revivification is much diminished. The blood in the body no longer comes into necessary contact with the atmospheric air introduced by respiration into the lungs. If the action of chloroform is prolonged until respiration ceases, we are not even sure of being able to revive the person, after having reëstablished the respiratory movements; for these often again cease, owing to the disturbance of the circulation, while these same movements, if restored after the inhalation of ether, become always more frequent in the patient when left to himself. Prof. Schiff affirms that, in the present state of science, the medical man *is responsible for every case of death occasioned by the application of ether*, because a careful watching of the respiration is capable of preventing death, while the fatal effect of chloroform depends, in part, on individual predisposition, which the physician is unable to recognize.

Animals and Fire-arms.—That crows and many other species of birds have little fear of man when he is unarmed is a familiar fact, and suggests that they fear him chiefly because of the weapons he carries. In Scotland, where shooting was prohibited on Sunday, crows and rooks were gentle, and fed around buildings without concern. Singularly enough, the same thing was observed of animals by Dr. Tristram when traveling in the wilderness of Moab, where the sound of a gun is quite rare. He says: "We were struck with the sagacity which all the wild animals showed in the matter of fire-arms, little familiar as they can be with them here. As it was Sunday, we strolled or sat down among the ruins without our fowling-pieces, and were consequently objects of indifference. A fine fox sat and looked at us a dozen times among the stone-heaps, and just walked away, keeping almost within gunshot all the afternoon. The Sakkr falcon sat calmly on his favorite perch, and allowed us to reconnoitre him on Sunday, while the eagle, owls, sand-grouse, and partridge, showed a similar contempt for unarmed Europeans."

The Temperature of the Ocean.—Dr. Carpenter recently delivered a lecture before the London Royal Institution, on the "Temperature of the Ocean," showing, from the soundings made by the Challenger Expedition, that the difference of climate between Northwestern Europe and the North American Atlantic seaboard is due not to the course of the Gulf Stream, but to the circulation of the waters of the Ocean between the poles and the equator. The shores of Northwestern Europe have the benefit of the northward movement of the warm superficial stratum, while the temperature of the American coast is lowered by the surging up against it of deep glacial underflow. The fact, he says, comes out most clearly from the Challenger soundings, which had been suspected by the United States Coast Surveyors, that the cold band which separates the Gulf Stream from the United States coast is really continuous with the cold strata that lie at some depth beneath the Gulf Stream, and this continuity explains the presence of the cold band which was previously wanting. For, as any flow of water from the equator toward either pole will tend toward the east in virtue of the excess of easterly momentum it brings from a part of the globe where its rotation was rapid; so any flow of water proceeding from either pole toward the equator will tend toward the west, in virtue of that deficiency of easterly momentum which it derives from a part of the globe where its rotation was less rapid. In this surging upward of the deeper and colder stratum lying beneath the Gulf Stream, we have very distinct evidence of its southerly movement. The precisely similar cold band which has been observed by Captain St. John to separate the Kuro Liwo, or warm Japan current, from the coast, may be fairly attributed to the same cause.

Action of Frost on the Position of Trees.—The elevation of the trunks of trees was the subject of some observations by Mr. Thomas Meehan at a recent meeting of the Philadelphia Academy of Sciences. On a previous occasion he had attributed this elevation to the natural thickening of the roots, which brought them in contact with unyielding rock beneath, the necessary consequence being that they would then lift the entire tree. Since that time he has been led to offer another explanation, viz., the action of frost. Most trees standing by themselves, he observed, have the collar of much greater diameter than the trunk above, and the upper portions of the roots, springing from about the collar, are considerably above the surface of the ground. That this is caused by the action of frost is rendered probable by what we know of its action on minor vegetation, what is called "drawing out." When the land freezes, expansion ensues, drawing up with it the roots of clover, and leaving of course a cavity from which the root was drawn. At the first thaw the liquid, carrying earthy matter, enters the cavity, and then the clover-root is prevented from descending to its original position. The same is true of trees. Roots, heaved up by frost, find the cavity beneath partially filled, and hence the tree will stand a little higher than before. Dr. Latham, State Botanist of Wisconsin, is of the opinion that large trees blow over much more readily than younger ones with the same proportional weight of head to development of roots, chiefly because the older trees have been drawn nearer to the surface. One of the chief offices of the tap-roots is probably to prevent the tree being lifted too high by the frost. Dr. Meehan is inclined to think that the trees of tropical climates have by no means so great a development of tap-roots as those of more northern regions. This question he proposes to investigate further.

Topography of the Bed of the Pacific.—Soundings made by the United States Steamer Tuscarora, between San Diego, Cal., and Honolulu, S. I., show this part of the Pacific to be a basin with precipitous sides and a comparatively level bottom. In the first 100 miles west from San Diego, there appear to be two valleys and two peaks. The first valley is from 622 to 784 fathoms deep, the first peak 445 fathoms, the second valley 955 fathoms, and the second peak 566 fathoms. Thence a precipitous fall takes place, giving, in latitude 31° 43′ north, longitude 119° 28′ west (Greenwich), 115 miles from San Diego, a depth of 1,915 fathoms. After that there is a gentle slope, with comparatively unimportant interruptions, at the rate of three feet to the mile, to the point of greatest depth, 3,054 fathoms, at a distance of about 400 miles east of Honolulu. The sharpest elevation is a rise about midway between the United States and the Sandwich Islands, in latitude 26° 30′ north, longitude 127° 37′ west, the highest portion of which is 2,159 fathoms below the surface. At the next cast of the lead the valley to the west of this elevation took 2,650 fathoms. The fall of the side of the basin, east of Honolulu, is even more remarkable than the descent off the American coast. Fifty miles from Honolulu soundings gave 498 fathoms; 40 miles farther east, in latitude 21° 43′ north, longitude 156° 21′ west, the depth was 3,023 fathoms. Between the last-mentioned point and that of greatest depth a hill rises, on whose summit there are only 2,488 fathoms of water.

The Origin of Hair-Snakes.—Dr. Slack, in the *Turf, Field, and Farm*, satisfactorily answers the question put by a correspondent, as to the origin of the so-called hair-snake or hair-worm. The common belief is that these creatures are a transformation of a horse-hair that has remained for some time in water. "When a walking-stick," says Dr. Slack, "becomes a snake, a horse-hair will become a worm. As the former miracle has not taken place since the departure of the Israelites from Egypt, it is safe to conclude that the latter transformation has not recently been made. A dry hair placed in water will absorb the moisture, and, from the unequal expansion of the exterior and interior layers, will become contorted; so too, would a piece of two-inch rope, yet we have never heard of the latter having been accused of possessing vitality. The hair-snake is a living creature, endowed with organs of locomotion and respiration, and capable of propagating its species. Scientifically it is known as *Gordius aquaticus*, the generic name being derived from the Gordian knot, in allusion to the tangled appearance often presented by a multitude of these animals. The specific name *aquaticus* is not so appropriate, for they thrive out of water." Dr. Slack has taken Gordii six inches in length from the body of a grasshopper. They have also been found in the stomachs of insectivorous birds.

Cast and Wrought Iron Stoves.—A commission of the French Academy of Sciences has been investigating the hygienic effects of the use of cast-iron stoves. Experiments were made with stoves of wrought and cast iron, using soft coal, with the view of learning under what conditions stoves of metal became unhealthy, through the presence of carbonic acid and carbonic oxide, in the rooms heated by them. Rabbits were made to breathe the air passing over stoves of cast and wrought iron heated to redness, and afterward the blood of the animals was chemically examined, to ascertain the presence of carbonic oxide. The report states that, though the results of experiments made upon rabbits do not enable us to fix with precision the proportion of carbonic oxide absorbed by their blood, nor that of the oxygen which has been expelled from it, still they show that the use of cast-iron stoves, at a red heat, causes in the blood, by the presence of carbonic oxide, a gas eminently poisonous, changes whose repetition may become dangerous; while the same method of investigation has not revealed analogous effects from stoves of wrought-iron. In summing up the results of the entire series of experiments the commission reports as follows:

"The carbonic oxide, whose presence has been proved when stoves of cast iron are used, may arise from several different causes: 1. The permeability of the stove by that gas, which will pass from the interior of the fire-pot to the exterior. 2. The direct action of the oxygen of the air upon the carbon of the cast-iron heated to redness. 3. The decomposition of carbonic acid contained in the air by its contact with metal heated to redness. 4. The influence of the organic dust naturally contained in the air." The commission recommend that all stoves and heating apparatus of cast-iron, and even of wrought-iron, be lined with fire-brick, or other substance, so as to prevent their attaining a red heat.

South-Sea Surgery.—In some of the South-Sea Islands a method of surgical treatment is adopted in certain cases which would bear away the palm, as a torturing process, even from the dreaded *moxa*. The following description of the South-Sea operation is from the London *Medical Times:* "The wise men in these islands have invented a theory that headache, neuralgia, vertigo, and other affections of the head, arise from a crack in the skull, or from pressure of the skull upon the brain. The remedy which they have contrived consists in laying open the scalp by a T-shaped incision, and then gently scraping away the cranium itself with a piece of glass until the *dura mater* is reached, and a hole is made in the skull as large as a silver dollar. Of course, if the operation is carried a little too far, the patient dies; and this appears to be the mode in which most of the cures are effected, death being the result in about half the cases operated upon. The hole is usually covered with a piece of cocoa-nut shell, scraped thin, and placed under the scalp. Formerly, the instrument employed was a shark's tooth, but broken glass is found to act better. Bone-scraping is also resorted to as a cure for rheumatism in old people. The skin is cut open, so as to lay bare the bone supposed to be affected, and the surface of the latter is then scraped until a portion of the external lamina is removed. Here surely the remedy is worse than the disease."

New French Life-saving Raft.—An extraordinary safety-raft has recently been invented in France. It is described as large enough to support from 400 to 600 persons, as neither incumbering nor requiring any alteration in the arrangement of vessels, and as needing only a minute or two to inflate and launch it. It is an air-tight mattress, with a surface of nearly 900 square feet, inflated in one minute, it is said, from a reservoir fixed in the engine-room, and always charged with air under a pressure of fifteen atmospheres. When not in use it is rolled up, and takes no more room than a boat. When inflated it falls over the side of the vessel, against which it is retained by ropes till all the persons on board are transferred to the raft. Three strong spars, passing through the whole length of the raft, keep it flat and solid.

Training Shepherd-dogs.—Sheep-raisers in California have an ingenious system for training dogs to guard their flocks. In Southern California one may wander for miles, and see thousands of sheep without a single shepherd to watch them, but around each flock half a dozen dogs. These have the entire care of the sheep, drive them out to pasture in the morning, keep them from straying during the day, and bring them home at night. These animals have inherited a talent for keeping sheep, and this talent is cultivated in the following way: When a lamb is born, or the shepherds have a pup which they want to train, the lamb is taken from its mother, she not being allowed to see her offspring, and the puppy is put in its place, and the sheep suckles it. When the puppy grows old enough to eat meat, it is fed in the morning and sent out with the sheep. It stays with them, because it is accustomed to be with its foster-mother; but it cannot feed with them, and, as they get full, the dog grows hungry. At length, impatient to return, in hopes to get its meat, the dog begins to tease and worry the mother, and finally starts her toward home; the others follow, and thus the whole flock is brought in. If they are brought home too early, or the dog comes without them, he gets punished in some way; and thus, by taking advantage of their instincts and appetite, these dogs are trained to a great state of perfectness, and become invaluable to the owners of large flocks.

Legislative Blunders.—The *Pall Mall Gazette* thus indicts the English Public Health Act of 1872: "Its failure, now that this has become too clear to be disputed, turns out to be of a more than usually instructive kind; for it shows that, contrary to all expectation and probability, there was, in 1872, still a blunder remaining for us to commit in sanitary administration, and that we have since committed it. We had already exhausted every source of administrative inefficiency which is to be found in inadequacy of powers, defects of initiative, and obscure intricacy of law. We had set up sanitary authorities who could not act, authorities who would not act, and authorities who did not know when, where, and how to act: it remained for us to establish authorities who could and must act, and then to misdirect and mislead them into a confusion worse than inactivity. Having failed in every possible way at the circumference, we had yet to fail at the centre, and we have done it."

Skunk-Madness.—Rev. Horace C. Hovey, in the *American Journal of Science*, gives some novel results of a protracted inquiry concerning the common skunk (*Mephitis mephitica*). He says that, at times when the animal is unable, either from exhaustion or other reasons, to produce that secretion whose stench is its great defense, its bite is productive of a highly-dangerous rabies, often causing death with some of the terrible symptoms of hydrophobia. We have thus authenticated the fact that rabies, capable of being given by the inoculation of a bite, is communicable by the canines, felines, and the mustelidæ families.

How Plants imbibe Ammonia.—From a series of experiments made by Adolf Mayer, it appears that plants have the power of absorbing ammonia through their aërial parts. The experiments were made on plants growing in such a manner that no ammonia could reach their roots directly, while the leaves were subject to its action, in either a gaseous or dissolved condition. It was observed, however, that the plants did not thrive when the access of ammonia to the roots was entirely prevented.

Reproduction of Organs in Fish.—Darwin, in his "Animals and Plants under Domestication," states, on the authority of Frank Buckland, that, when portions of the pectoral and tail-fins of various fresh-water fish are cut off, they are perfectly reproduced in about six weeks. This phenomenon of regeneration was recently observed in the aquarium of the Boston Young Men's Christian Union, by F. W. Clark, who communicates to the *American Naturalist* an interesting note on the subject. It appears that, in the spring of 1873, a fish-fungus made its appearance in the tank, and several fine fishes died. Among the specimens attacked by the fungus was a young goldfish, which, by some unknown means, had lost its tail-fin. The fungus covered the whole stump of the tail; the fish became sick, and was apparently dying. Mr. Clark's attention having been called to the case, he at once concluded that he had some parasite to deal with, and resolved to exterminate it. He applied a few drops of nitric acid to the tail-stump, allowing it to remain a moment or two, after which he rinsed it off in clean water, and put the fish back in the tank. The parasite, of course, was killed; the patches of fungus sloughed off, and the fish was soon well. In the course of a few days, he thought he saw the fungus again appearing on the affected part; but, on looking closely, found that the appearance was really due to the growth of new rays. A month later, a new tail-fin, about a fourth of an inch long, had appeared, and, three months from the time of the experiment, the fish was undistinguishable from others of the same species in the aquarium.

NOTES

The American Association for the Advancement of Science will hold its twenty-third annual meeting this year at Hartford, commencing at ten o'clock, on Wednesday, August 12th. Members must furnish the permanent secretary, F. W. Putnam, Salem, Mass., with complete titles of all the papers they propose to present during the meeting, together with an estimate of the time required for reading each paper. Each title must be given on a separate slip of paper, with the full name of the author. The titles must be furnished to the secretary before the day appointed for the Association to convene. The Association will at this meeting accept the act of incorporation, giving it a legal existence. Another matter to come before it for deliberation will be the new constitution. From the *American Naturalist* we learn that a monograph on "Fossil Butterflies," by Mr. Scudder, is soon to be published by the Association, the necessary funds having been voted by the committee on Mrs. Thompson's gift. The officers elected for the Hartford meeting are the following: *President*, Dr. J. L. Le Conte, Philadelphia; *Vice President*, Prof. C. S. Lyman, New Haven; *Permanent Secretary*, F. W. Putnam, Salem, Mass.; *General Secretary*, Dr. A. C. Hamlin, Bangor; *Treasurer*, William S. Vaux, Philadelphia.

A correspondent of *Land and Water* relates an instance of a brood of chickens being cared for by a cat. This brood, having been hatched very early in the season, was taken from the hen and placed in a basket near a kitchen fire. Soon the chicks were missing, and, on search being made, were found in an up-stairs room, kindly tended by the domestic cat, being huddled close to her warm fur. They were returned to the kitchen, and, the cat still claiming them, she was left in possession of her adopted brood, which she raised to chickenhood. As they grew up the cat would accompany them in their out-of-door rambles, lying in the sun, and fondly watching them.

Good results have been obtained in the utilization of sewage at Dantzic. The land on which it is applied is nearly pure sand, and the yield of the sugar-beet grown on it is described as enormous, while the percentage of sugar is equal to that obtained from roots grown on the best soil in Germany. The decrease of the death-rate of the town is considerable, and the "waste" lands have been made to yield remunerative crops.

The forty-fourth annual meeting of the British Association for the Advancement of Science will be held at Belfast, commencing Wednesday, August 19, 1874. Prof. Tyndall will preside. In 1875, the Association meets at Bristol.

The annual wine production of the United States is estimated, in round numbers, at 20,000,000 gallons, and the market value at 14,000,000 dollars. The wine production of various States is as follows: California, 5,000,000 gallons; Ohio, 3,500,000; New York, 3,000,000; Missouri, 2,500,000; Illinois, 2,500,000; Pennsylvania, 2,000,000; Iowa, 400,000, and so on downward.

The *Lancet* expresses the opinion that oftentimes, in fatal explosions of petroleum, death is produced instantaneously by shock, combustion, and anæsthesia. Petroleum is a mixture of homologues belonging to the marsh-gas family, which for many years have been recognized as powerful anæsthetics. Some fifteen years ago an attempt was made to introduce one of them, the hydrid of amyl, as a substitute for chloroform.

In Corsica the octopus is an esteemed article of food, in fact, a "great delicacy." It is first boiled, and then roasted.

We are pleased to learn that Mr. J. P. Lesley has been appointed geologist-in-chief to conduct a new survey of the State of Pennsylvania. The results of this survey, as has been pointed out by Mr. MacFarland in a memorial to the Pennsylvania Legislature, cannot fail to be exceedingly important. A more competent man than Mr. Lesley could not have been found for the office of chief geologist.

The Royal Agricultural Society of England has made a grant of £100 to Prof. De Bary, of Strasburg, to enable him to make a special investigation into the life history of the potato fungus, *peronospora infestans*.

The third meeting of the French Association for the Advancement of Science opens at Lille, on the 20th of August, continuing till the 27th. Prof. Ad. Wurtz, the distinguished chemist, is president of the Association for the current year. The local committee includes the chief notabilities of Lille and of the Department du Nord.

Another new artificial stone, according to the *Mining and Scientific Press*, has lately been brought out in California. The process of manufacture is not given, but it is said to be simple and cheap. The stone is impervious to moisture, fire-proof, and presents a fine appearance. It may be manufactured on the spot where it is wanted for use, and, requiring no subsequent handling, blocks of any size can be employed.

With the present year the series of annual international exhibitions at South Kensington, London, will cease. According to *Iron*, the undertaking appears to have been *managed* to death, the meddlesome tinkering of the commissioners having driven otherwise well-disposed manufacturers and tradesmen out of the exhibitions.

M. Planchon, with whose labors our readers are familiar, has succeeded in tracing directly to an importation of American vines into France, in 1862, the Phylloxera pest now ravaging the vineyards of that country. He has found at Roquemare a plantation of 154 American stocks, which dates from that year. All the other vines in the neighboring districts have been nearly destroyed, while these American stocks are intact. Though their roots are covered with the parasite, their foliage and fruit are very good. It was at Roquemare that the grape-vine disease first made its appearance in 1863, and then extended in every direction. It begins to be admitted now in France that the only protection against the Phylloxera is to be found in the introduction of American vines.

Articles on which flour-paste has been used are often injured by rats, even after the paste has become dry and hard. This can be prevented by mixing a small quantity of corrosive sublimate with the paste. Those who have tried this pronounce it harmless to persons handling it, and a complete safeguard against the rats.

In his work on the "Influence of Forests," Ebermayer gives a table of observations showing the temperature of the earth covered by snow during the extremely cold weather of December, 1871. He states that on the 8th and 12th of December, 1871, the temperature of the air fell to 26.8° Fahr., while the temperature of the earth beneath the snow was no lower than 33.8°, and four feet below it was 42.8°.

The seventh meeting of the International Congress of Prehistoric Archæology and Anthropology, will open at Stockholm on Friday, August 7, 1874, and will continue till Sunday, August 16th. The government of Sweden gives 20,000 francs to defray the expenses of the Congress.

Dr. JOHN L. LE CONTE.

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NATURAL HISTORY OF MAN.

By A. DE QUATREFAGES.

TRANSLATED BY ELIZA A. YOUMANS.

V.—*Intellectual Characters.*

GENTLEMEN: I resume my discourse for the fifth time on the same subject. You have already, on four different occasions, studied man; and, again, man is the subject of this lecture.

On the preceding occasions I ran over some of the general questions that arise concerning the history of the human race. Depending always and exclusively upon science, I have shown that this species is unique; that all men are of the same species; and that, in consequence of this fact, they ought to regard each other as brothers, whatever the color of the skin, whatever language they speak, whatever country they inhabit.

This species at first occupied a very limited part of the globe. It spread all over the globe at an earlier epoch than was formerly believed; more recent researches have demonstrated that man existed in France along with the hyena, the elephant, the rhinoceros—that is to say, along with animals seen, in our day, only in distant countries.

As man appeared at first on a restricted point of the globe, and is found to-day everywhere, it is evident that he has traveled in all directions from his *centre of creation*, and peopled the earth by migration much as do the Europeans at the present time. These journeyings have exposed him to all the influences which can be encountered on the surface of our planet, and he has become acclimated everywhere as we see him to-day.

In the study of general questions relative to the history of our species, we had to ask what was the origin of man.

On this point I have been obliged to confess the insufficiency of actual knowledge. But, if I was not able to say whence man came, I could say, in the name of science, whence he did not come; I could affirm that our ancestor was not an animal—neither a monkey, nor a seal, nor any other animal whatever.

At our last meeting we commenced the study of the general characters presented by the human species, and we examined its *physical characters;* that is, those which may be drawn from the body studied in a state of health and of disease. We were led also to pass in review its exterior characters, its anatomic characters, physiological and pathological. We thus obtained an idea of the general nature of man, considered exclusively from an organic point of view. Well, this study of man, in his material relations, led us to the conclusion that there is but one human species, so that it confirmed the results at which we arrived in our first lectures.

But is the body all of man? And, after studying the material being that strikes our senses, is there nothing more to study? Science will answer.

When a naturalist studies ants, he is not content with describing the thorax, the abdomen, the jaws, and the legs. He shows also how they construct their ant-hill, and to what use its chambers are destined; its galleries, where so many and such divers things are stored; he shows, further, how they raise their larvæ and their young ones; how they hold in captivity the plant-lice destined to furnish an aliment which they secrete, as do the cows and sheep we keep in our stables.

When a naturalist gives the history of bees, he does not limit himself to a description of their body and wings; he is careful to show how they build their hives, gather and knead the wax to construct the comb in which they deposit honey, the first sweet known to man. He calls the attention of the reader or listener to that unique female, always alone in each hive; he shows the respect and care that all the bee-workers have for this female, who is at once their queen and their mother.

In other words, the naturalist studies the instincts of the ants and the bees.

When he attempts the history of man, shall he put aside that which in him represents these instincts? Evidently not.

Consequently he must not stop with the body. He must consider the intelligence which is in us, and which, up to a certain point, we have in common with animals; he must show that it is this element of our being which recognizes the outer world, which judges, which aspires. His work will be very imperfect, if he neglects this something of which the nature escapes us, but of which the power is such, that through it man has not only vanquished all animals, whatever their defenses, their size, or their strength, but he has overcome and made to work, as his servants, even the immutable forces of the inanimate world, achieving all distances, thanks to the railroad! outstripping time, thanks to the telegraph! and even annihilating pain, thanks to chloroform!

Then, along with the material characters which we studied at our last lecture, we now take up intellectual characters.

It is our distinct intention, in taking up characters of a nature so new, still to remain exclusively on the ground of science.

We know the existence of faculties, and we shall point out their most general manifestations; but we shall have no concern with the nature of these faculties. In a word, we are not philosophers. Here, as in preceding lectures, we shall remain a man of science—a naturalist, and nothing else.

It will be impossible for me to examine these characters in detail. I shall neglect several, and limit myself to saying something on language, on writing, on the fundamental forms of society, on industry, and on dress.

I. *Language.*—It will not be denied that the most essential of all the manifestations of intelligence is language.

"Animals have voice, man alone has speech." This phrase is from an ancient philosophic naturalist—from the great Aristotle, who lived some four centuries before our era; it is as true to-day as it was more than two thousand years ago. In fact, man alone possesses articulate speech.

But, you all know that the manifestations of speech vary from people to people. Each of these manifestations—the languages, as we call them—constitutes one of the most essential characters of the different human groups. You all know a German, a Spaniard, an Englishman, by his language. But this is not the limit of the scientific importance of this character. Unhappily, I cannot here enter into details. I shall only attempt to show you, in a few words, how the study of language throws light on the history of human groups, even in the case of those who have lost all historic data.

You know that in France other languages than French are spoken, and that, on all sides of us, we find the Gascon in the south, the bas-Breton in Brittany, the Alsatian in Alsace, etc. Whence comes this diversity of language among a people at present so remarkably homogeneous?

History answers this question. It teaches us that, until a certain epoch, Languedoc, Alsace, Brittany, formed so many separate states, having each its own language. From this fact we are enabled to draw important consequences.

When we encounter a group actually designated by a single name, and when we find in this group secondary groups speaking diverse languages, we may almost to a certainty conclude that formerly all these secondary groups had their individual life, their political independence.

The study of language conducts us still further.

When, in place of mere juxtaposition, each remaining in the place it has occupied for an indefinite time, the different nations, from any cause whatever, come to be mixed together, they each bring their language; and, in consequence of the fusion, each brings his part of the language that becomes common. A language so formed is a mixed language, which consists of words and turns of phrases recalling the mother-languages which gave it birth.

Here, again, history shows us that this thing has actually been done. The English language, for example, has words and expressions which bring to mind the languages of all the races that have been mixed and confounded in that isle.

Consequently, when we enter for the first time a country of which we know not the history, and find a population presenting in its language words and phrases borrowed from other languages, on the right and on the left, we are authorized to conclude that this population results from the mixture of anthropological elements, which imply the linguistic elements themselves.

We may go still further.

Language, you know, changes—is transformed with time. The French language of our day is not the French of five centuries ago; the Frenchman of to-day must study specially and with dictionaries before he can read the French of the past.

So, language alters, changes, even when there has been no displacement of population. And all the more when immigration intervenes; if mixtures occur, the language will be altered, and a new language will arise. This new language may differ so much from the primitive one as to appear at first to have no resemblance to it. This may happen not only for one people and for one language, but for many. A language may also become the mother of many different languages. But these daughter languages always preserve something in common with that from which they descended; and men who have made these questions the object of continued study, the linguists, know very well how to discover the filiation. They know how to rise from derivative languages to their primitive tongues. In this way they attach together people that were thought to be very distinct because they spoke languages that at first seemed very different.

It is by this study, wholly recent, but which for some years has advanced with the stride of a giant, that we are able to unite in one source most of the people who now cover almost the whole of Europe; such as, on the one hand, the French, the Germans, the Swedes, and the Spanish; and, on the other, the people who inhabit Persia and the valley of the Ganges. These people constitute what is called the Aryan race.

More marvelous still, thanks to the comparison of languages, a philosopher of Geneva, M. Adolph Pictet, was able to trace a sort of history of the primitive Aryans, the common parents of Europeans, Persians, and Indians. He retraced their manner of life, and, although they left no historical data, he has shown almost in detail the point of civilization at which they had arrived.

I cannot, you know, enter into details relative to this science, at once so recent and already so immense that it has been called comparative linguistic science. I can only indicate the great divisions, because, perhaps I shall, by-and-by, have to refer to them.

All the languages spoken on the surface of the earth have been divided into three fundamental groups; these are the *monosyllabic languages*, the *agglutinative languages*, and the *flexible languages.*

The monosyllabic languages are the most imperfect. Each of their words consists of one syllable. As an example, I will name the Chinese, which is a monosyllabic language, *par excellence.* In this language each word presents itself with a sense perfectly absolute, and the delicacies of our language, even the distinctions of time, of place, of going, of coming, etc., can be translated only by a kind of paraphrase.

The agglutinative tongues form the second stage of language; here there are words, placed after the fundamental conception, which serve to modify the primitive sense—roots, to employ the expression in use. As examples of agglutinative languages, I will name the negro languages, and those spoken by yellow people, and also by very small numbers of white people.

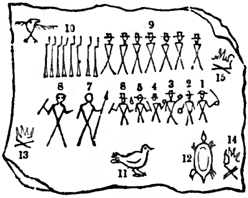
Finally, the highest development of language is that of flexible language, so named because, by simple changes in the termination of a word, we can change and modify the absolute sense, and make it express divers shades of meaning, thus: *I speak* now; *I shall speak* to-morrow. Almost all the white races speak flexible languages.

II. *Writing.*—Speech is evidently the first element in the formation of societies; writing is the most essential element of the progress of these societies. It is speech *fixed.* This alone permits the transmission of the results of our efforts to the most distant descendants—of the accumulation of the treasures that each generation has separately acquired. I should like to dwell upon its history; but I should be drawn too far, and so, for writing as for language, I can only indicate a few facts.

Almost with the lowest savages we find means to aid the memory, and serve as *souvenirs* of events to which more or less importance is attached. These are called *mnemonic* signs. They are sometimes stones, sometimes pieces of wood shaped in divers ways. A mode of appeal to the memory, found in both the Old and the New World, consists in uniting packages of strings of different colors, on which are made knots of divers forms. These are called *quippus.* You make, so to speak, a quippu every time you tie a knot in your handkerchief to enable you to recall something.

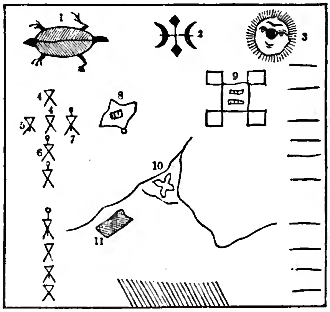
Picturing objects, men, events, in a more or less faithful manner, is not writing; it is what is called *pictography*. Such are those gross representations employed even to-day by the Indians of North America to transmit information (Figs. 1 and 2.)

Fig. 1.



Indian Bark-letter.

Fig. 2.



Indian Bark-letter.

Explanation of Fig. 1.—On one occasion a party of explorers, with two Indian guides, saw one morning, just as they were about to start, a pole stuck in the direction they were going, and holding at the top a piece of bark, covered with drawings, which were intended for the information of any other Indians who might pass that way. This is represented in Fig. 1. No. 1 represents the subaltern officer in command of the party. He is drawn with a sword, to denote his rank. No. 2 denotes the secretary. He is represented as holding a book, the Indians having understood him to be an attorney. No. 3 represents the geologist, appropriately indicated by a hammer. Nos. 4 and 5 are *attachés*; No. 6 the interpreter. The group of figures marked 9 represents seven infantry soldiers, each of whom, as shown in group No. 10, was armed with a musket. No. 15 denotes that they had a separate fire, and constituted a separate mess. Nos. 7 and 8 represent the two Chippewa guides. These are the only human figures drawn without the distinguishing symbol of a hat. This was the characteristic seized on by them, and generally employed by the Indians, to distinguish the *red* from the *white* race. Nos. 11 and 12 represent a prairie-hen and a green tortoise, which constituted the sum of the preceding day's chase, and were eaten at the encampment. The inclination of the pole was designed to show the course pursued; and there were three hacks in it below the scroll of bark, to indicate the estimated length of this part of the journey, computing from water to water.

Explanation of Fig. 2.—This figure gives the biography of Wingemund, a noted chief of the Delawares. No. 1 shows that it belonged to the oldest branch of the tribe, which use the tortoise on their symbol. No. 2 is his *totem*, or symbol; No. 3 is the sun, and the ten strokes represent ten war-parties in which he was engaged. Those figures on the left represent the captives which he made in each of his excursions, the men being distinguished from the women, and the captives being denoted by having heads, while a man without his head is of course a dead man. The central figures represent three forts which he attacked; No. 8, one on Lake Erie; No. 9, that of Detroit; and No. 10, Fort Pitt, at the junction of the Alleghany and the Monongahela. The sloping strokes denote the number of his followers.

When the object figured has a conventional signification, we may say that writing has begun. For example, the idea of prudence would be represented by a serpent, that of force by a lion. This manner of translating thought is symbolic, ideographic writing. It presents many stages. The hieroglyphics seen on Egyptian and Mexican monuments belong here. But all these signs do not constitute veritable writing.

In reality, this appears only when the signs employed represent the sounds of the language. After reaching this point, writing again presents two very different stages. Each syllable may have its particular character; or, better still, the elements of the syllable may be represented. This last form constitutes writing, properly speaking. It is this that we employ. The collection of signs we call an alphabet; and this alphabet, which constitutes the first step of elementary instruction, is certainly one of the most marvelous inventions of the human mind. So almost all the ancients attributed to it a divine origin.

III. *Primitive Forms of Society.*—As I just said to you, it is by language that societies begin, and by writing that they make the greatest progress in civilization. But, before they attain civilization, they have long halting-places to get over, and, regarding the *ensembles* of the human races, we see three very distinct kinds of primitive society.

The lowest degree of human association is people that hunt and fish; and this inferiority is easily explained. A society composed entirely of hunters cannot be numerous, because it must live on the game it kills. Therefore, a great space is needed to nourish a sparse population. Besides, the hunter's chances are for the day; he is never sure of a living for to-morrow. This incessant uncertainty prevents him from directing his intelligence toward more elevated subjects. Hunters, besides, have incessantly to watch their hunting-grounds to prevent encroachments. In other words, the hunter is the image of war. Wars easily arise between neighboring populations placed in identical conditions. These wars are without mercy, for each prisoner is one more mouth to feed; kill him, then. Hence, hunting-tribes are almost inevitably courageous, sometimes heroic, but warlike and cruel.

As soon as man domesticates certain animals—cattle, sheep, or llamas—as soon as he becomes pastoral, his to-morrow is assured. He can at once begin to occupy himself with something besides his food; and we see societies of this kind begin to make progress. However, pastoral people need vast spaces for their animals; these promptly exhaust the herbage of a canton; it becomes needful to go elsewhere after food for the animals which supply milk and flesh, the nourishment of the master, and so a pastoral population cannot exist in great numbers. They easily become nomadic. In their migrations the hordes meet and dispute by force of arms for the precious pasturage. War breaks them up; but prisoners may be utilized by the conqueror, and their food will not be a great sacrifice. They are spared, and slavery is born.

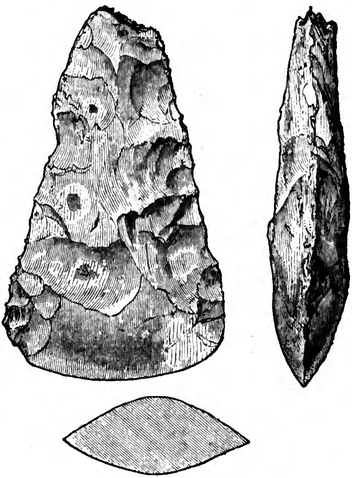
Society takes its third form, when man finds that the vegetable kingdom furnishes more abundant and reliable food than that obtained from animals—when he becomes an agriculturist. Besides, agriculture gives him leisure. His manners soften. War, when it breaks out, becomes less cruel. Prisoners employed to work in the field can render services more and more considerable. Slavery becomes serfdom. Relieved from imperious material necessities, the intelligence of the master awakens and enlarges. A true civilization may arise and grow among agriculturists.

Centuries ago Europeans attained a social state permitting the degree of civilization of which we are so proud, and this leads me to make an observation.

Too often, under the influence of our actual superiority, we disdain the people who are behind, whether in the pastoral state or in the state of hunters. We proclaim them incapable of reaching our level.

This opinion is nowhere justified. Forget not that we have passed by the same halting-places. Forget not, above all, that many civilizations have preceded our own. Two thousand years before our era the Chinese raised monuments that still excite the admiration of travelers, cultivated the mulberry, raised the silk-worm, and possessed notions of astronomy. Egyptian civilization is still more ancient. You saw proof of this at the Universal Exposition. In the temple raised under the direction of N. Mariette you must have admired, among other things, that magnificent statue of Chefren placed at the bottom of the hall, and which dates 4,000 years before our era. At this time we were true savages, covered with the skins of beasts, and carrying on our persons, under the pretext of embellishing ourselves, paints and tattooing like those of the most backward races of our own day. The effect of this should be, on the one hand, to awaken our modesty, and on the other to render us indulgent to people who are yet at the point which we have escaped.

Fig. 8.



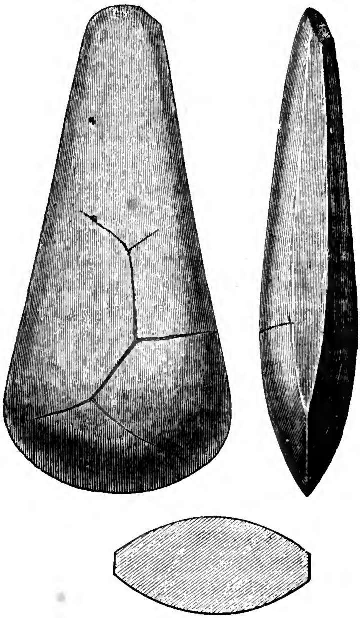
IV. *Industries.*—It is in the midst of primitive societies that industries are born and flourish. However low a people may be, it always has its own proper industries. Man is essentially an industrious being.

All industries suppose utensils; and the matter of which these utensils are made furnishes the means of determining to a certain extent the degree of civilization attained by people whom we know only by traces they have left.

In the beginning we see stone alone used to fabricate utensils and weapons; for these two things proceed together. Everywhere, man is at first content to shape more or less perfectly matter furnished him by the soil. Look at these samples of stones (Fig. 3) which have served as hatchets, whether for domestic use or war. You see they are fashioned very simply. These objects came from our soil; they served our first ancestors and attest the truth I have just stated.

In proportion as man progresses, he is not content simply to shape the stone; he polishes it. His first attempts in this way are coarse enough. At first the edge of the hatchet alone is polished. Later the entire hatchet, and sometimes in a remarkable manner (Fig. 4).

Fig. 4.



The hatchets as well as the knives are generally of silex, that is, of that species of stone which formerly served as flint in striking fire. Its hardness explains why it was chosen for these purposes. When it began to fail they could employ others. Finally they fell back on shells, and it is impossible not to admire some of their works executed with such imperfect instruments, with fragments of stone less hard than our silex, and the *débris* of marine shells. After stone, appeared the metals; but not iron, of which we know so well the uses and which alone has made possible the miracles of our modern industry. Copper and bronze preceded iron; in America copper, in our Europe bronze, came after stone.

Fig. 5.

Boomerang.

Finally, iron made its appearance, and many evidences prove that from its first discovery its value was understood. In the gymnastic plays celebrated by Achilles on the tomb of his friend Patroclus, at the epoch of the Trojan War, twelve centuries before our era, a mass of iron is proposed as a prize, and Achilles himself speaks of its importance.

The diversity of material employed in utensils marks the true stages in the history of ancient peoples. At this time we generally admit as distinct periods the age of stone, the age of bronze, the age of iron. The age of stone is divided into two periods, according as the utensils and weapons were polished or only shaped. It is to this most ancient period that the population belonged which lived in Europe with the elephant and rhinoceros.

I must refer you to the special history of the several races for further details of their industries. But I will add a few facts to the preceding. Let us speak a word about the warlike industries.

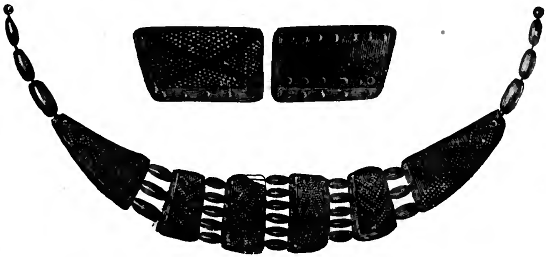
Wherever human society exists, we find instruments of war. After the need of food, it seems the most pressing want of man is to kill or enslave his kind. We may say that man is a warlike being.

Among the lowest people of the globe we find offensive and defensive arms; and everywhere those at the bottom of the scale astonish us by the ingenuity of these arms. The Australians, certainly a most inferior people, use a not very large but very thick shield. Their skill in parrying strokes is most remarkable, as all travelers admit. The same people use curious weapons; one, called the *boomerang* (Fig. 5), is a bit of hard wood, very flat, sharp, and more or less curved. The inhabitants know how to throw this little piece of wood so that, after it has struck the enemy or the game, it rises in the air, turns, and falls into the hand of the thrower. The boomerang realizes, then, the enchanted arms spoken of in the old fables—arms which, after having struck the mark, come back themselves to their possessor.

V. *Dress.*—If I point out some facts relative to dress, it is to show you how much of connection, of real resemblance, there is between the most savage and the most civilized people.

Everywhere and always man has sought to embellish himself. Sometimes by acting on himself, sometimes by borrowing the elements of his dress from without. In the tombs discovered from time to time which inclose the remains of men with their stone hatchets, used in France against the elephant and rhinoceros, in those tombs, I say, we find collars (Fig. 6) made of morsels of shells or small corals

FIG. 6.



NECKLACE.

which had not, in the eyes of their possessors, a less value than the precious stones have for us. We might almost define man as a being who ornaments himself; and certainly here is a great difference separating him from the animals. I shall not dwell on the different materials taken from the exterior world to cover our bodies and embellish us. Were you to see a woman of Tahiti in grand costume, you would remark that when our grandmothers had contrived the panniers, and the women of our day the crinoline, they only borrowed from the children of the South Sea a part of their attire.

It is worthy of attention that, under the pretext of embellishing himself, man has almost always sought to modify his own body. So the Chinese women, in order to make their feet very small, cripple themselves in so grave a manner that often the little children succumb in the operation. The bones of the heel, in place of elongating behind, are violently displaced and directed downward, so that the women walk on their own heels as on the heels of their shoes. The toes are likewise turned under, the big toe alone being in place. Our women do not go so far; but you know women who, to make the feet small, fear not to give themselves corns, and many men do the same.

At the Philippines, the group of isles that you see at the east of Asia, is a people whose women attach great importance to having the largest possible fist. To make it large, they swaddle the arms, which consequently remain slender, while the fist enlarges in a fashion very repulsive to our European eyes.

But the head seems to have been, by preference, the object of these strange caprices, probably because it is the part of the body most evident and most important. Some people seek to change completely the form of the cranium. For this purpose they place on the heads of children, immediately after birth, contrivances which project them forward or backward, and then, by pressing tightly behind and before, the head is made flat. There is a people on the western side of America which surrounds the head of the infant with a bandage so as to give it the form of a sugar-loaf.

I must remind you that among ourselves the ears are still pierced to suspend ornaments from them. If men have generally renounced this fashion, women remain very faithful to it. But all the other parts of the visage have been submitted to the same mutilations, the nose, the lips, the cheeks themselves have been pierced, always to suspend or introduce into the openings some morsel of wood, of stone, of bone, as ornament.

Fig. 7.

Head of New-Zealander.

Fig. 8.

Head of New-Zealander.

The face and the forehead are frequently decorated with divers tattooings (Figs. 7 and 8), made sometimes by pricking, sometimes by cutting the skin. At the Marquesas Isles, not only the countenance, but the entire body, is tattooed. You see here a warrior (Fig. 9) of that country, and perhaps you think him covered with a motley costume; no, it is simply tattooing.

Jest not too much at these ornaments of savages. Our ancestors wore the same, and the fashion is not wholly effaced with us. More than one of you, doubtless, has on the arm or on the breast some red or blue figure representing a heart pierced, two swords crossed, an anchor, or a hammer, symbols of your profession.

Along with these tattooings incrusted in the skin by various processes, we may place also the paintings. Here, again, is a means of embellishing that every people has practiced and practices still. Some-

FIG. 9.

CAROLINE ISLANDER.

times these paintings have precise significations; there are the paintings of war, the paintings of peace, the paintings of *fêtes*, etc. We do not go so far; but we must not forget that the most civilized Europeans have painted and still paint the countenance. Our grandmothers habitually used white, and, above all, red; they put on patches, that is to say, small rounds of court-plaster to give beauty to the skin by contrast. And to-day, you know, our fashionable women tint themselves so well that a word has been invented on this subject. So we find, in our most elevated classes, that which seems so strange in savages.

The head of hair offers the same considerations. With savages as with us, it is an object of no less special care. Negroes, Hottentots, Polynesians, etc., stiffen their hair with grease, and color it with pow-

Fig. 10.

Fijian Modes of dressing the Hair.

ders, red, yellow, white, etc. (Fig. 10.) Everywhere they decorate it with flowers, feathers of all sorts, brilliant crystals, grains of glass. Well, our fathers pomaded and powdered themselves; our women pomade themselves, and put flowers, feathers, and diamonds, in their hair, which are, after all, only crystals, more or less dear. And as to our pomades, whatever name we give them, they always have, for foundation, the oil of almonds, or the fat of pork. You see that, between the article used by savages and that we make ourselves, there is no great difference.

III. *Moral and Religious Characters.*—We pass to another order of characters. By his body, I repeat, man is an animal, nothing more, nothing less; by his intelligence he is infinitely superior to animals. But, to judge by fundamental phenomena, the nature of our intelligence does not differ from that which they manifest.

Are we, then, only a more intelligent kind of animal? I have already answered this question. No; we are not animals, we are something else; for, besides the phenomena which we have in common with them, we have our special character, connected with faculties, of which we find not the least trace in the most elevated animals. These faculties are *morality* and *religion.*

I. *Morality.*—Among all people, in all races, there are expressions which mean good and bad, honest man and scoundrel; consequently, all men have the abstract notion of good and evil.

Objections have been made to this idea that morality was an attribute of man; or, rather, difficulties have been raised on the subject. Some say, for example, that animals know also what is good and what is bad. This is true for our most perfect domestic animals, as the dog. Thanks to our superior intelligence, we have accustomed them to that which is good and bad *for us.* But leave them in a savage state, and you will never find them doing any thing to which you can attach the notion here implied. Man is certainly the only being that we see war against pain—physical evil—that he may reach moral good.

It has been said again that morals differ from people to people, and the attempt has been made to draw from this an inference that morality is not characteristic of man. The faculty itself is here confounded with its manifestations. We forget that the same sentiment can be expressed by very different and sometimes opposite acts. I will take, for example, those which testify to politeness and the respect we pay to superiors. In the same case, the European rises and uncovers his head; the Turk, on the contrary, remains with the head covered, and the Polynesian sits. These contrary acts are not less, the one than the other, acts of deference.

We must place ourselves at this point of view to judge of morality. We must, in such cases, and, above all, when it is a question of inferior peoples, forget our own notions on this subject, and seek after the general ideas of the people we are studying. We must recur to what has taken place with us at certain epochs, and then we shall find that there is not as much difference as we imagined between the most civilized and the most savage people. We shall return to the subject in treating the history of races. To-day I can only say a few words relative to three chief principles: *Respect for property, respect for the life of others, and respect for one's self.*

I. *Respect for Property.*—It has been said that the notion of property does not exist among savage people. This is an error. With them, arms, utensils, instruments, are strictly personal property, as with us; but some travelers have been deceived by the existence, among hunting-tribes, of another kind of property, communal property, if I may so speak. Among these people the ground does not belong to the individual but to the entire tribe. Under this relation the property is so well known that war is the consequence of the least violation of the hunting limits.

Certain races have been accused of being essentially thievish. This reproach is brought particularly upon the negroes of the Gulf of Guinea, and upon the Polynesians. They have been accused of stealing even the nails of the ship. But let me remind you what iron is for people who do not have it. It is more precious to them than gold. Well, suppose there should arrive among us a ship, gold clad and nailed with diamonds and rubies. Do you believe it would go out intact from our ports? Remark further, that, among the negroes of Guinea and Polynesia, those who steal of their comrade are dishonored and punished as they would be with us. They have the idea of respect for property the same as ourselves.

II. *Respect for Life.*—Everywhere the life of man is sacred; everywhere the murderer is punished; but, with ourselves, circumstances determine the nature of the act. Nobody would treat as an assassin him who beats fairly in a duel; the soldier who has killed with his hand a great number of enemies is decorated; very far from being punished, he is recompensed. With savages the formula is still more elastic. For him the stranger is always an enemy; besides, vengeance is in his eyes a virtue, and when he has a murder to avenge he cares little to strike the murderer himself. Provided he furnishes a member of his family or his tribe, his vengeance is satisfied; whence results the *bad blood* between European travelers and the Polynesians in particular. These people have too often complained of violence exercised by Europeans, who have left without being punished. The savage watches for those who come after the really guilty, sets a trap for them, and massacres the innocents. He applies his moral law, and we find the theory horrible. But forget not our middle age; we have got the start a little, but, in our day, if the *vendetta* were not abolished in Corsica, it would be the same, as it was the same in Scotland between clan and clan.

For the rest, gentlemen, the question of respect for the life of others is one of those that I least like to enter upon, because I cannot speak without blushing for the white race. You know that it rules everywhere, but some of you do not know, perhaps, that everywhere devastation and massacre have marked its steps round the world. It seems that it has used its superiority to annihilate its sister races, and reign on their tombs.

III. *Respect for Self.*—I have shown you that the evils of which we accuse the savages exist with us. Permit me to show you among them the good of which civilized people pretend to have the monopoly. The sentiments of honor and of modesty are certainly two of the most noble and most delicate of the respect due to one's self. We find these two sentiments developed sometimes in a high degree in the most savage peoples.

It is evident that the idea of modesty must vary from one region to another; it cannot be the same among people forced by the climate to go naked, and among those who are compelled, by the rigors of climate, to wear clothes. We ought, in this respect, to look for marked differences, and to take account of these exigencies; besides, from the nature of the subject, I cannot enter into details, and I will only say that more than one traveler has expressed his astonishment to find more of true modesty among naked savages than among civilized and well-clothed people.

Honor is, perhaps, the sentiment which is most uniformly manifested among these people. To obey the sense of honor, they hesitate not to provoke torments, to brave, and even to solicit, death. A young Kaffre chief is condemned to death; he may be pardoned on the condition of losing his ostrich-feather, which for him represents epaulets; he demands, as a favor, to be thrown to the crocodiles rather than be dishonored. The red-skin made a prisoner, attached to the post of torture, defies his enemies to extract from him the least sign of suffering.

That which we call chivalric generosity exists among the most savage peoples. Two Irishmen quarreled one day with some Australians; they were without arms. Instead of profiting by this advantage, the savages gave them arms, that they might defend themselves.

In our war at Tahiti, Admiral Bruet, commander of the French forces, took a bath one day in a river of the interior of the isle, while a well-armed chief belonging to the enemy was concealed near by. When peace was gained, this chief came to see the admiral, and easily showed him that for nearly two hours his life had been in his power. "Why did you not draw?" said the admiral. "I should have been dishonored in the eyes of my people," replied the native, "if I had killed by surprise a chief such as thou."

See how the people called savages often conduct themselves. Would we do better?

You see, gentlemen, and you may fearlessly say, to the honor of our species, that morality, in its more serious as well as in its more delicate aspects, is found among all men; and, decisively, man is a moral being.

II. *Religion.*—I come now to another order of considerations, that it will perhaps surprise you to hear me discuss. I have said, at different times, that I wished to be a man of science, that I did not wish to enter here upon either philosophy or theology, and yet I am going to speak of religion. I shall continue faithful to my programme. It is as a naturalist that I shall take up the subject. As for morality, I showed the existence of the faculty; then I pointed out some general facts, reserving the special facts for the history of races. To-day, as heretofore, I shall avoid with care the dogmatic and the theologic side of the discussion.

The first fact to establish is the universality of the manifestations which belong to religion. In every country, with all peoples, in all races, we find the belief in beings superior to man, and influencing his destiny for good or evil. Everywhere we find the belief in another life succeeding to the actual life. These two notions lie at the foundation of all religions, and whoever admits them is religious. We can say, then, of man generally, that he is certainly religious.

Objections have been made to the generality of this character. Let us rapidly examine the case.

Some authors affirm that there exist atheistic people. They have cited in proof the Australians of whom I have already spoken, and the Bushmen. These are mistaken assertions; but this error may be explained. Three causes, acting together or separately, have contributed to a misunderstanding of the religious beliefs of the inferior races of humanity.

The first is the beliefs of travelers. When these travelers are missionaries, having an ardent faith but a narrow intelligence, they are easily led not to accept, as true, religious beliefs so different from their own. Often, in their eyes, these beliefs are a work of the devil; they put them aside, or do not take the trouble to discover them, and they offer us, as atheistic, people who certainly are not.

Ignorance of the language often leads to regarding a people as atheistic. A traveler encounters a savage tribe; he puts questions, well or ill, often by signs alone, on the Deity, or on the soul; the natives do not understand, and reply by some gesture of negation, and the traveler concludes that they believe neither in God nor immortality.

But, the great cause which has often led to the conclusion I am opposing, is the disdain of Europeans for savages. Generally, the European, proud of his knowledge, and overrating his superiority, judges in advance their incapacity to attain to notions a little elevated. He takes no great pains to discover what he believes does not exist. At the first failure he thinks himself right in concluding that these inferior races are incapable of attaining to the notion of God and of a future life.

Happily there are some tolerant missionaries who have studied them more closely, and laymen who have been able to see brothers in these inferior representatives of the human family. Thanks to the intelligence of these patient, clear-headed men, we now know that these Australians, that were said to have no idea of God, have in reality a rudimentary mythology, which sometimes recalls our own European superstitions. We now know that the Bushmen deify their great men, and address prayers to them. As to the Bushmen, they have a remarkable idea of the Divinity. They regard him as a great chief, who resides in heaven. They say of him: "We see him not with the eyes; we feel him in the heart."

This last phrase, which I quote literally, was obtained by travelers who lived in the midst of these people. They show that sometimes the people justly placed in the lowest rank of the human races may have, along with the strangest superstitions, religious notions remarkably elevated. This fact is often presented when we examine the religion of different peoples. We find, it is true, much that is *bizarre*, many strange and shocking things, but we find also behind these absurdities ideas and beliefs which astonish us by their seriousness, by their elevation, by the resemblance they offer to that which is believed by more advanced people.

The negroes of Guinea may serve to illustrate this subject. All travelers have spoken of their absurd beliefs, all have spoken of their fetishes. They tell us how these people prostrate themselves before serpents, trees, bits of wood, bone, etc., carefully wrapped up, and on which their priests have performed certain ceremonies. There are few who would seek that which might be found at the bottom of all this. Those who have made the search have found religious ideas, very superior to these appearances; the belief in divinities of different orders, living in the skies, and presided over by a sovereign creator who made every thing. When we look still further, as M. d'Avezac has done, we find prayers conceived in terms such as a European, a Christian, might repeat without blushing. In the case of these negroes, as in our own, we must distinguish between religion and superstition, two extremely different things, which are too often confounded. I will add but a few words.

Gentlemen, I close to-day the first part of the lectures that I have undertaken to give you. Let me formulate the last conclusions.

We have asked only general questions, those which bear on the entire human race, and which may consequently conduct us to the foundation of the nature of man. We have asked them exclusively from the point of view of natural science; we have studied man as we study an animal or a plant. The result of this examination is to show in man a *résumé* of the entire creation.

In him we find phenomena exactly parallel to those encountered in minerals, in plants; consequently, all the forces acting in minerals and plants we find in man.

By his body, from an anatomical and physical point of view, man is an animal, nothing more, nothing less; hence all the animal forces act in him.

But is it by his body that man has acquired that empire that we have seen he possesses? You know very well it is not; you know very well that, if he reigns over all around him, over inanimate Nature as over organized Nature, he owes it to his intelligence, of like nature, but immensely superior to that of animals.

Finally, man has his own attributes—faculties that belong exclusively to him—morality and religion. Well, these exclusively human faculties seem admirably to complete this exceptional being. It is these that ennoble him, and justify the incontestable empire that he claims over the globe; for it is these which, along with the sentiment of punishment, give birth to the idea of duty, the thought of responsibility.

Here, gentlemen, is the summing up that one is led to make of man when he is studied exclusively from knowledge by the naturalist. I hope you will find that you have lost nothing.

THE PHOTOSPHERE AND SUN-SPOTS.

By Prof. S. P. LANGLEY,

DIRECTOR OF THE ALLEGHANY OBSERVATORY.

WHY is it that almost any one who was offered the opportunity of witnessing an eruption of Etna, or the effects of a tropical cyclone, would embrace such an occasion with eagerness, while phenomena so similar in kind, and on so far grander a scale, visible daily on the surface of the sun, excite a comparatively feeble interest in all but those devoted to their study?

It is doubtless, in part, because we have a more intimate and awe-inspired interest in disturbances which happen so near us, and which we do not extend to others with which we conceive we have less personal concern; but the difference of the kind, as well as the degree of our interest in solar phenomena, from that which we take in those which occur, as it were, at home, is due in part perhaps to a remoter cause, and forms a portion of the unconscious bias which the modern mind has inherited from ancient modes of thought.

Deeply impressed by the fact that the sun had warmed and lighted the world from unknown time, with a fire which never seemed to be fed, yet which never burned low like a terrestrial flame, ancient philosophy concluded that the sun was formed of something quite other than any gross earthly elements—of an element of pure fire, which shone and warmed forever without fuel, because it was its "nature" to; just as it is the "nature" of a fire on the hearth to burn only when fuel is supplied to it. The sun was, then, to the ancient world, a kind of supernatural phenomenon, interest in which partook more of the uninquiring awe due to an immediate miracle of Deity, than of the curiosity excited by a fact of the natural world; and whatever we may think of such a way of regarding the matter, the view of the ancient philosophy, that the sun was an immaculate orb of pure fire, self-sustained, continued to be accepted almost as a dogma of the faith down to times subsequent to the dawn of the modern philosophy.

When one of the first, possibly the first, of the observers of sun-spots, Christopher Scheiner, a Jesuit, communicated his discovery to his provincial, the latter, Mr. Proctor relates, answered: "I have read Aristotle's writings from beginning to end, many times, and I can assure you I have nowhere found in them any thing similar to what you mention; go, therefore, my son, tranquillize yourself, be assured that what you take for spots in the sun are the faults of your glasses or your eyes."

Perhaps we are, however unconsciously, ourselves in some degree Aristotelians in such matters, and it is at least certain that the unrecognized influence of ancient modes of thought has delayed progress in solar physics, by preparing astronomers to admit theories which they could not have accepted with a clear recognition of the fact that physical laws are the same in the sun as here, however erroneously we learn them from our limited terrestrial experience. In the hypothesis of Wilson, for instance, that exhaustless flow of solar light and heat is made to come from a shallow stratum of brilliant cloud, surrounding a dark and presumably cold and solid globe. The elder Herschel adopts this hypothesis, with slight modification (it is not yet quite dislodged from the text-books), and even his eminent son appears to feel nothing like an imperious demand for a sustaining cause of the almost infinite flood of heat his own researches showed that these clouds must be giving.

It seems *now* extraordinary that men justly eminent as the Herschels could rest satisfied with an hypothesis which so evaded the consideration of the fundamental problem of the equality of the solar radiation, by tacitly assuming the suspension there of the most familiar laws of terrestrial experience.

The views now generally accepted contemplate the sun as hot throughout its mass, and in such a mass as containing indubitably an enormous though finite reservoir of heat. And, if, so far at least, there is an agreement even among those who differ as to the way in which this heat originated and is maintained, much is due to astronomers like Faye, who have insisted on this recognition of the need of accounting for the equable emission of heat with a success which may make us underrate our obligations to them, as this need, once enunciated, is so clear as to seem a truism, though it was far from being such till a very recent period.

We must, then, look at the sun with no more idea of witnessing any thing without the sphere of natural laws, than in looking at a fire across the street. It need not follow that we shall find the operation of those laws exactly the same that our limited experience has presented, and we shall still find abundant cause for admiration and wonder without introducing mysteries of our own creation.

When we telescopically examine that brilliant surface which we see daily with the naked eye (the photosphere), to study such of its phenomena as are here described, we do not need the spectroscope, but some means of protecting the eye from the blinding light and heat, and this should not involve the use of any colored shades. If we look into an unsilvered glass, as, for instance, into the panes of a shop-window from the street, we observe that it acts as a mirror, sending back a feeble reflection of ourselves, or other objects without; most of the rays from which have gone altogether through the glass, while a comparative few are returned to form the image. It may occur to us, then, instead of looking directly at the solar image formed by our telescope, to let it fall on a piece of plain glass, placed diagonally, through which about nineteen parts in twenty of the light will pass and be thrown away, the remaining twentieth being reflected and forming an exact though enfeebled image.

When this has been done, if the reflected image be still too bright, we may reflect it again, this time only a twentieth of the first twentieth reaching the eye, and so on to any degree; but it is strikingly illustrative of the intensity of the solar splendor that, when, by three such reflections, the sunlight has been enfeebled 8,000 times, we yet find it intolerably bright. Instead of more mirrors, it is better to now arrange that the third mirror may rotate, so as to *polarize* the light. When this is done, the image of the sun appears distinct (if the optician have done his work well), colorless, and of any brightness desired.

The instrument just described in general terms is known as the polarizing eye-piece. All danger and discomfort in studying the sun disappear with its use, and we may look at its unclouded face as though the eye had been strengthened to bear its light; in fact, many hours of scrutiny of the solar disk with this instrument wearies the eye less than a few minutes' telescopic examination of the moon does without it.

What we shall see with it is far from being that sphere of dazzling light, everywhere equally brilliant, which we have been accustomed to consider the sun. The eye ranges over a vast surface, presenting at one view over five thousand times the entire area of our globe, to find everywhere diversity of shade. It is not only darker near the edges than at the centre, but the whole (apart from any consideration of the spots) presents an appearance somewhat like that very peculiar one which the ocean has when we obtain a bird's-eye view of it from some great height.

Any one, for instance, who has looked down upon the Mediterranean from the summit of Gibraltar or Capri, and can recall its curious unlikeness to its familiar aspect—its apparent stillness, the faint intricate bands of white and gray, which, thus seen, overlap it like a net-work of broad veins, and the strangely permanent patterns left by the foam, which are entirely lost to us as we approach its tossing surface—will have a not wholly inadequate idea of the first impression made by the sight of the photosphere. If we bring ourselves nearer, as it were, by an increase of magnifying power, we lose sight of the larger masses of light and shade, whose place is filled by a curious mottling of faint, inextricably confused, and intermingled moss-like patterns.

With the best optical aid, and in those rarer moments when our own atmosphere is comparatively tranquil, we discern that the whole of these cloud-like mottlings are composed of very minute definite oval forms, which have been compared to grains of rice.

Minute as they appear, their real size is very great; for, though in a large telescope they seem mere dots, the average area of each is certainly much over 100,000 square miles. Since we see them at all, it must be owing to some inequality of brightness which distinguishes them, and, in fact, they do not seem to be in absolute contact, but present rather the appearance of numberless little white clouds, arranged with a sort of order upon a background of darker sky, or, if we compare them to rice-grains, we may suppose the grains arranged in rude tesselated patterns upon a gray cloth.

The most extraordinary conjectures have been hazarded as to the real nature of these objects, which are of somewhat recent discovery, and which are so difficult of observation that few have distinctly seen them. Whatever these things may be, they are the principal source of the sun's light, and presumably of its heat, and this adds to the interest of their study.

The writer has given a considerable time to their observation, which can only be carried on successfully by patient waiting, and the employment of those scattered moments when the ever-perturbed atmosphere of the earth is relatively still. He has been led to conclude that these bodies are composed of still smaller forms, and that their total area is inconsiderable compared with that of the whole sun, for, though it is almost impossible to determine the aggregate space occupied by such minute things, the writer has been led to conclude that it can hardly exceed one-fifth of the solar surface, and may be much less. An inconsiderable part only of the solar light comes from the relatively dark background on which they appear, and, in reference to these still mysterious things, we may, then, partly adopt an expression which Huyghens used with regard to the faculæ, and say that there is indeed in the sun "*something brighter than the sun itself.*" The expression will not appear a forced or exaggerated one if we reflect that (if we rely on the correctness of the observations just alluded to) the average brilliancy of each of these bodies cannot be much less than *five times* that of full sunlight, "sunlight" itself being, in fact, caused by a dilution of their brilliance with that of the gray background which has been just compared to the cloth on which white grains are grouped.

There are inequalities in the brightness of these bodies, some of which fall below, while others as certainly exceed, the average. If we remember that each of them occupies an area larger than Great Britain, that this area is, throughout, *brighter than the sun* (in fact, not in metaphor), and that such enormous bodies, whatever they may be, exist in the sun in numbers which are almost incalculable, we reach up to some idea, but doubtless an inadequate one, of the incomprehensible vastness of the solar sphere, and of the interest of the problems it offers for our study.

In order to examine these bodies under other conditions, we must look at a sun-spot. Here, again, we find it difficult to conceive the vastness of the field of operations, for, including both branches, the "spot" represented in our engraving covers over 1,000,000,000 square miles. If we fail utterly to "realize" the extent this represents, we may, perhaps, derive aid from its comparison with some familiar terrestrial object. In the small circle, accordingly, the continents of North and South America have been drawn on the same scale as the spot, as they would appear; that is, if they were actually transported to the solar surface, placed beside the spot, and viewed, together with it, from the distance at which the earth is from the sun.

The engraving is from a drawing by the writer. This drawing, while representing the general outline of a particular spot, seen in March, 1873, embodies the result of many previous studies on similar ones, and it has been made much less with an attempt to gain pictorial effect than to truthfully present such features as will help to give some idea of the constitution of the solar surface.

We see that each branch of the spot consists of two main parts, an outer (the *penumbra*) and an inner (the *umbra*), and beyond this rude division little seems to have been observed till recent years. The knowledge of the real complexity of spot-structure and the fullness of detail needed to represent it are of such recent origin that Sir John Herschel, who, in the Cape-of-Good-Hope observations, has given a number of sun-spot drawings, points out, in one of them, the tendency to a radial structure, as something remarkable and nearly unnoticed; and the fact that so eminent an observer should have made the spots his careful study without detecting more of the structure since discovered, will illustrate the difficulties attendant on such an investigation. If we look at this, not merely as at a picture, but in the way in which we should examine a geological map, with the purpose, that is,

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of studying the superficial details as indices of the real nature of the structure, we are naturally led to inquire whether the surface before us is a solid like one of our continents, or a fluid like our seas, or a vapor like our clouds. We know, at the outset, from abundant evidence, that the temperature of the sun, whatever it may be, is far above that at which the materials chiefly composing the earth's crust would become fluid. It is, then, at the outset, an unlikely supposition that the surface of the sun should be solid; but, independently of such considerations, the behavior of this, or any other spot, is decisive as against this alternative. It was formed and grew to its present size in a comparatively short time, and, according to past experience, it will shortly break up and disappear.

Besides its rotation *with* the sun, the spot has an absolute motion *on* it, advancing, as a whole, at a greater angular velocity round the solar axis than spots nearer its poles, besides having a slight oscillating movement, which carries it alternately nearer to and farther from the sun's equator; all this going on simultaneously with changes in its form and size. The spot then moves about on the sun as a ship on the ocean, or, to employ a less inaccurate simile, like a rent in the clouds of our sky, which, while turning with the earth, both shifts its place and alters its appearance from hour to hour, the spot not being something above the sun's surface, but a gap in and below it. We seem irresistibly led to the conclusion, then, that the surface of the sun is not a solid, and, considering this freedom of motion, we are led to question if it can even be a liquid, and whether we must not look upon it as wholly vapor-like.

But we may approach the spot and look within it for answers to these questions, though, as we do so, the reader should distinguish between the facts stated and the inferences drawn from them. As to the former, observers may be said to agree with little exception; as to the latter, astronomers are, in some cases, at variance, and what follows is chiefly confined to a statement of fact, since a review of opposing hypotheses would not be at present in place.

The approach to the spot is scarcely marked in the engraving by any variation of the surface; though there is, in reality, a very slight blurring of the luminous masses (rice-grains) which makes these look less distinct as we draw near the edge. Here, all at once, the appearance changes. We are approaching what is really the outer rim of an enormous shallow funnel (that shown is 20,000 miles across); shallow, that is, in the outer portion only which is saucer-shaped, while the spout of the funnel is indefinitely deep. The first or gentle slope is the penumbra. It does not shade off into the photosphere, but begins, as has just been said, abruptly; and this sudden transition is a thing to be noted. We also observe that the edge is extremely irregular—full of indentations and subdivisions, patches of the photosphere pushing out here and there over it, and at times apparently hanging suspended above the abyss.

The sides of the slope are filled with what seem at first sight like long white threads, radially disposed, so that a circular penumbra, looked at casually, has somewhat the appearance of the iris surrounding the pupil. A closer look shows that these threads are not arranged exactly radially (in some spots not at all so). They are often contorted and thrown over each other, and evince a tendency to curl into sickle-shaped curves as they approach their inner extremities; while, if we examine them at the penumbral circumference, we find them to be apparent prolongations of those minute white objects to which the light of the sun has just been referred.

These "threads" or "filaments" are difficult of observation, for their average thickness is probably not over 200 miles, a width quite invisible at the sun's distance, in any thing but a very good telescope. Some appearances make it probable, however, that they are composed of filaments still finer, just as the finest silk thread is made up of numerous fibres, and they have a certain disposition to unite in fascicles, which are often mistaken for them. The dimension of 200 miles, then, is somewhat an arbitrary one, marking perhaps rather the present limit of vision of our telescopes than any real limit of the actual size; but, however this may be, the extraordinary length of these filaments is not open to question; they are quite commonly met with three or four thousand miles long, and the writer has occasionally distinctly traced one of these attenuated forms uninterruptedly through a much greater distance. What they are is still unknown.

What are the forces which cause the spot to move as a whole upon the solar surface, and what are the nature and direction of those which modify its form, and so completely change in a few days, or even hours, the disposition of its parts over its so vast area? To the first question there is, as yet, no satisfactory answer, though our knowledge, such as it is, seems to point to a constant interchange of matter between the surface of the sun and its interior, far within which seem to be impressed on the ascending currents velocities of rotation which so modify those which obtain at the surface. As to the second, the spectroscope, if appealed to, offers but very partial help, and we here restrict ourselves to a description of methods which do not involve its use. How may we determine the *directions* of the currents which we cannot doubt exist within the spot?

It has happened to the writer to be lost in one of the shallow, labyrinthine lakes, in the interior of our Northern wilderness, on whose still waters the canoe was left to drift aimlessly with the wind, while the guide sought, at first vainly, the traces of some current which would indicate the direction of the outlet; till, looking below the surface, the common direction of the extremities of the water-grasses, rooted at the bottom, showed the existence and direction of a current otherwise unperceived, and gave the question its solution.

The long filaments of the penumbra may be used in a similar way, flexible as they are, and rooted, as it were, at one end, while the other sways in the currents of the solar atmosphere, yielding to it as freely as the grasses to the water, or a streamer to the air; and the analogy is noteworthy in this: that one end of the filament is commonly made fast, while the other is left free. This is so very generally the case that we see that, if these filaments be clouds, they differ from ours in other circumstances than their shape. Those we are studying are bent into curves, which show that the solar winds frequently move in circular sweeps, and are, to a considerable degree, comparable with our cyclones. Long, twisted ropes are sometimes formed by them, one being thrown over another; and, in cloud-like masses, they at times move over and conceal lower portions of the penumbra—the abrupt changes in the directions of motion showing us that these are superposed strata of what, for want of a better word, we must call solar clouds, which drift across each other's course occasionally, nearly at right angles, while the ever-moving whirlwinds leave an unmistakable record of their action on these pliant forms.

In one part of the spot, one of these has been bent into a complete loop, or closed curve, the extremity showing a fringe of ragged strands, like that of a broken rope. The immensely more extended scale of the action here being kept in view, and the fact that the whole spot is being changed in all its parts—even while we are looking at it—by alterations which, though apparently gradual, are really the indications of an immense energy, it will be seen that, considered merely as a spectacle of the play of natural forces, we have before us something almost incomparably greater than any which the terrestrial volcano, earthquake, or cyclone, can offer. The entire surface of the earth, were it spread out into a plain, would be, in fact, of inconsiderable size as compared with either branch of the spot we are examining.

The quickness of the transformations that the observer sometimes notes here is wonderful. Lockyer, Young, and other observers, have demonstrated the existence of chromospheric movements, in some instances, at the rate of over 100 miles a second; and the velocities in the photosphere are, occasionally, of a similar order of magnitude. As an instance, it may be mentioned that the loop in question, which inclosed an area of about 3,000,000 square miles (not far from that of the United States), broke up, and seemingly melted away, like a snow-wreath before a fire, in little over a quarter of an hour. How vain the attempt must be to adequately realize to ourselves the features of such a cataclysm seen close at hand!

It is quite impracticable to convey an adequate idea of the complexity, strangeness, and beauty of these penumbral forms by an engraving; and the description is likely to fail equally, both on account of the unlikeness of the appearances to any thing with which we are familiar, and the difficulty of using any descriptive terms which, drawn from terrestrial analogies, will not here prove inaccurate. A plume-like form, in the upper portion of the spot, is necessarily but an imperfect memorandum of an appearance, in reality all but impossible to render with the pencil, even on a scale which depicted it a hundred times this size. It might be likened to a sheet of glass, covered with the most intricate and capricious patterns the frost ever traces on our window-panes in winter; but, together with this, there was something flame-like in the graceful terminal curves, and something strangely suggestive of fern-like vegetation about the whole. This double and apparently incompatible impression of something at once crystalline and plant-like is strikingly conveyed by many of the penumbral forms, and yet the description will doubtless appear incongruous to any but the few who have seen for themselves. The comparison of the frost-figures is the least inapt, perhaps, to be found, but it is really impossible to obtain an accurate one, when we have no single thing on earth which we can exactly liken it to. When we consider that this extraordinary shape occupied a greater area than the North and South American Continents united, while that, over the whole, obtained a temperature far above that of the white flame which plays about the mouth of a furnace, and that its parts turned, as the observer looked, from one evanescent beautiful form to another, with a rapidity of change which indicated the existence of inconceivable force, we need feel less surprise that any metaphor, necessarily drawn from our limited terrestrial analogies, should so fail to convey an adequate idea of what the writer is certain he has seen, but confesses he cannot properly describe.

The *umbra*, or dark inner shade, commences as abruptly as the penumbra, but the contrast between it and the penumbral edge is far greater than between that and the photosphere. We possess no very accurate photometric determinations of the relative light of these portions of the spot, and nothing seems practicable beyond a rough averaging where the umbræ are themselves of such various tints. If we adopt the somewhat crude determinations of the elder Herschel, we may assume that the penumbra is, as a whole, rather less than half as bright as the photosphere, and the umbra about one-seventieth of the brightness of the penumbra. More accurately, if we represent the average brightness of the photosphere by 1,000, that of the penumbra will be denoted by 469, and that of the umbra by only 7. The umbra appears, at first sight, to be black, but this is only from contrast with the superior brightness around it. It is certain, for instance, that sunlight is at least 200,000 times brighter than moonlight (probably more). The umbra, then, if it be but seven thousandths of the brightness of the surface, is still 1,400 times (at least) as bright as the moon, or far brighter than the calcium-light. The absolute depth of the inner edge of the penumbra, below the surface, is not very great, according to M. Faye, and probably not over from 2,000 to 4,000 miles. (Every thing is relative; and, on the sun, 2,000 miles is little for the depth of a cavity which may be from ten to twenty times this width.)

Somewhere about this lower level commences the umbra, which has been already compared to the spout of the funnel, of which the penumbra formed the upper shallow cone; and, through these umbral shades, the eye looks down to quite unknown depths.

The darkest parts are far from being black, however they may appear by contrast, the very "blackest" part being radiant with a light which would appear intolerable to the unshielded eye. Brown and reddish tints are occasionally seen here with the polarizing eye-piece. These, the spectroscope shows, are due to incandescent hydrogen; but a common tint, which is particularly that of the nuclei or deeper umbral shades, is a very pure violet.

It is impossible to do more, in such an article as this, than to outline, in the briefest way, a few of the more prominent appearances of the spots and solar surface, without attempting any description of the laws which regulate their respective motions, and the emission of their light and heat, and without alluding to the numerous other topics of interest to the student. The reader will not, it may be hoped, on this account derive the impression that his attention has been invited to a description of superficial solar phenomena, merely as spectacles. In this point of view alone, certainly, we cannot contemplate them without lively wonder, but their deeper interest will lie in the light they shed on the nature of the sun itself, and the laws which govern that flow of light and heat through which alone we ourselves live and move. Experience seems to indicate that, according as these wonderful phenomena are studied with or without the spectroscope, they are assimilated more, in the observer's mind, with such terrestrial motions as those we call eruptions in the first instance, or cyclones in the second. It would be generalizing from a partial view, therefore, to present the reader with any single hypothesis at present, especially while those versed in the study find so much that, on any hypothesis, is still mysterious.

FERMENTS, FERMENTATIONS, AND LIFE.

By FERNAND PAPILLON.

TRANSLATED BY A. R. MACDONOUGH.

I.

UNTIL very lately, all fermentations were supposed to be produced by the spontaneous decomposition of organic matter within a fermentable liquid. It was said that on contact with air this organic matter undergoes a special change which gives it the character of leaven, and this was regarded as an agent having the power of spreading decomposing movement. It is true, brewer's yeast had long been well known; the facts of its cellular composition and its organization were familiar; but no relation was recognized between this organized condition and those phenomena of fermentation produced by yeast in saccharine liquids, such as grape-juice or the wort of ale. In the first few years of this century Turpin, and afterward Cagniard-Latour, attempted in vain to prove that such a relation existed; it was always denied that any thing else could be observed in alcoholic fermentation than an operation resembling all those slow decompositions that were classed among fermentations. We have admitted, in our time, that alcoholic fermentation, instead of being an exception, is on the contrary the very type of the phenomena we are treating of; that the yeast-cells, far from being unimportant, take an essential part in it, and that in all fermentations whatever there occur low organizations, microscopic corpuscles, more or less analogous to those of yeast. At least this is the first result of investigations carried on in the past fifteen years by several men of science, among whom in the first rank M. Pasteur is to be cited.

M. Pasteur began the course of his labors in 1858, by the study of alcoholic fermentation. He placed it beyond a doubt that, in the case of grape-juice or beer-wort, as in that of any other saccharine liquid exposed to the air, the more or less rapid production of alcohol is always connected with the production of a microscopic fungus, consisting of rounded globules, a few thousandths of a millimetre in diameter. These globules, known under the name of brewer's yeast, multiply in the fermenting liquid at the expense of the organic matters it contains, and, by the exchanges of growth they give rise to, produce decomposition of the sugar into alcohol and carbonic, succinic, and glyceric acids. These are the four invariable products of alcoholic fermentation. Sugar is the food of the yeast-fungus; these products are its excretions. The laws of the inner mechanism that elaborates them are yet unknown. But every thing leads us to believe that the yeast-cells secrete a substance more or less resembling those that work out the phenomena of digestion in the higher animals. Alcoholic fermentation would thus be a kind of digestion of sugar within the globule.

M. Dumas, who signalized his entrance upon the career of studies in natural science half a century ago, by memorable discoveries in microscopic physiology, has lately returned to researches of the same kind, precisely, in respect to fermentations. In M. Pasteur's laboratory at the Normal School he has taken up investigations on this subject, the results of which, quite lately published, show that the distinguished *savant* in question has lost neither his cautious diligence in experimental processes, nor his lucid conception in the grasp of principles. He has attempted among other things to determine the decomposing force, the amount of activity, possessed by each cell of the alcoholic ferment. To ascertain this, he measured the quantity of sugar decomposed in a given time by a fixed weight of yeast, and he found —after first establishing that a cubic millimetre of yeast contains about 2,772,000 cells—that the power of a million of cells represents the force capable of decomposing four grains of sugar in an hour. If we attempted according to this estimate to express in figures the number of cells employed in producing the wine, beer, and cider, consumed every year, as M. Dumas says, even astronomers would shrink from the task.

This active property of decomposing sugar, and forming alcohol in consequence, does not belong to the cells of brewer's yeast exclusively. Several chemical agents possess the same power, and certain vegetable cells also are adapted to use it. When fruits are placed in a medium filled with oxygen, they absorb this gas, and occasion the release of carbonic acid; if, on the contrary, they are left in carbonic acid or any other inert gas, they effect the production of alcohol. The fruits remain firm and hard, without suffering any external change, but the sugar they contain is transformed in part into alcohol. How is this phenomenon to be explained? In common air, the cell of the fruit is fed by oxygen; if this gas is withheld, it is forced to borrow the materials of nutrition from the fluids that moisten it, that is, from the saccharine juice, and then the latter is decomposed. M. Pasteur has noted that a similar alcoholic fermentation takes place in other vegetable organs, in leaves, for instance, and in every case he has proved that the phenomenon is due to the cells of the vegetables alone, and not to yeast-globules. Far from throwing any doubt on the physiological doctrine of fermentation, these singular facts agree in lending it support, by giving it deeper and more general application.

We have seen that the fermentation of sugar yields alcohol. The latter, brought in contact with certain porous substances, as, for instance, platinum sponge, can absorb the oxygen of the air and transform itself, by oxidation, into acetic acid. A phenomenon of this kind occurs in wine when it sours, the alcohol contained in it being changed into acetic acid; only, the agent in the transformation is in this case a microscopic plant, made up of little elongated globules, some thousandths of a millimetre in diameter. These globules, these mycoderms, develop on the surface of wine exposed to the air, and form a scum which plays the part of storing away a certain stock of oxygen, afterward used to produce acetification in the liquid. This scum, which is called mother of vinegar, only acts while in communication with the air. As soon as it is below the surface, it loses its efficacy, and the production of acetic acid is checked. Thus the development of vinegar in the acetic fermentation is reduced to an oxidation of alcohol, in which microscopic cells are the vehicles of the oxygen.

When milk turns and sours, that phenomenon also is due to the formation of an acid—lactic acid. This substance proceeds from the decomposition of sugar contained in the milk, and this decomposition, again, is a fermentation. The microscopic being that effects it assumes several forms; sometimes it is made up of cells presenting much resemblance to the cells of yeast, sometimes it consists of straight and exceedingly fine rods. Milk also contains casein, which is the substance that composes cheese, and, when the fermentation of the sugar in milk is over, that of the casein begins; after lactic acid, butyric acid is produced. Examining with a microscope the casein transforming into butyric acid, we observe in it little rods, two thousandths of a millimetre in diameter, and of a length from two to five times as great; this is the butyric ferment, which, concurrently with other microscopic vegetable growths, determines in various cheeses the slow production of butyric acid and several analogous acids, equally strong in smell. To cite a last illustration, the decomposition of urine, giving rise to an abundant release of ammoniacal gases, is also the result of a fermentation; under the action of cells smaller than those of brewer's yeast, the contained urea changes to carbonate of ammonia, rendering the liquid highly alkaline and strongly odorous. In short, the fermentations we have just described, and many others of the same kind, participate in the nutrition and development of microscopic beings, of an average size not exceeding some thousandths of a millimetre, and presenting the form sometimes of spheroidal or of egg-shaped globules (as mycoderms, torulacea), sometimes of straight, bent, or curving rods (as vibrios and bacteria). These diminutive beings engender the ferment within the fermenting liquid itself, in the degree and rate of their propagation in it.

There is another class of fermentations in which the immediate presence of definitely-shaped corpuscles cannot be traced. Thus diastasic fermentation consists in the transformation of starch into sugar under the action of a formless yellowish matter, called "diastase." Amygdalic fermentation is that in which amygdaline becomes the essence of bitter almonds, by the action of a like ferment, known as "syraptase." The former takes place in the vegetable embryo when the amylaceous matter of the seed is converted into a soluble sugar, which permeates the growing tissues of the plant. The latter occurs when bitter almonds are crushed in water; on contact with the liquid, the mixture of these odorless kernels takes the characteristic smell of the essence of bitter almonds, which results from the fermentation of amygdaline. We regard as fermentations, moreover, a certain number of similar phenomena which can be produced with the implements of a laboratory, and which are constantly taking place in living organisms, of which the cause is a zymotic substance. There exists, for instance, in the saliva a principle called ptyaline, which, like diastase, converts amylaceous matter into sugar. The gastric juice contains another principle, pepsin, which has the effect of liquefying albuminous substances, so that they may be prepared for absorption. The pancreatic fluid contains another principle which acts in a similar way. Digestion is thus reduced to a series of fermentations, as the ancient chemists had rightly conjectured in regard to it. These different phenomena, as well as those in which organisms take part, have the two general characteristics of fermentation; they occur only within certain limits of temperature, and the weight of the fermentable matter is always much greater than that of the ferment which suffices to decompose it.

To conclude, fermentations occasioned in certain media, by the act of development and nutrition of ascertained microscopic animal or vegetable existences, present a group of well-defined characteristics. They follow obediently all the variations that may occur in the physiological activity of the microscopic beings contained in the liquid. This does not go into fermentation all at once; it delays more or less, and molecular movement makes itself perceptible in it by degrees. The phenomenon is one of evolvement. This appears to be the characteristic of alcoholic, lactic, acetic, butyric, glyceric, and putrid fermentations—all of those, in short, which M. Pasteur has studied with so convincing accuracy. Is it the same with the conversion of amylaceous substances into sugar, under the influence of diastase or ptyaline, with the dissolving of proteic substances by pepsin, with the change of amygdaline into the essence of bitter almonds, by contact with synaptase? Evidently not. These phenomena present another aspect; they show no stages of evolvement. Doubtless they require a certain time for their completion; but they take place all at once, and without any relation to the surrounding air.

These differences between the two kinds of fermentation clearly depend on this: that, in the former, the phenomenon is subjected to the conditions and vital progress of those organized corpuscles which elaborate the ferment within the substance of the fermentable liquids, while, in the latter, the phenomenon is brought about by a ferment already formed and prepared. But this latter ferment is no less of organic origin; it, too, arises from living beings, animal or vegetable. Whether it emanates, like diastase, from the young cells of the seed, or results, like pepsin, from work done in the digestive apparatus, it is the labor of life, just as much as if it had been completed by globules of yeast or bundles of bacteria. Thus the efficient sources of all fermentations are the same. All ferments are at bottom alike, whether procured directly for the fermentable liquid by microscopic bodies inhabiting it, or emanating from corpuscles that inhabit elsewhere. The true doctrine of fermentations consists in this point.

Henceforth, then, we may consider ferments as products of a fecundation taking place in cells, as secretions elaborated by those myriads of infinitely little corpuscles, some crowded, squeezed, condensed, into the palpable organs of animals and plants—others free and moving, disseminated, as we shall see, into vast, intangible space. The energy which distinguishes these microscopic animal and vegetable growths also belongs to the microscopic elements making up the living tissues in the higher animals. We must give to this property, hitherto considered as special, the high dignity of a fundamental and universal attribute of organized cells. We must detect, in the most complex conversions and processes of nutrition in superior beings, the same untiring and primitive force that marks the subtile action of invisible and insignificant monads.

No doubt, the corpuscles of different species—to which, in the last analysis, we reduce animals and plants of every kind and degree—are not identical. Each species has its own structure, its specific energy, its mode of nutrition, its fixed secretions—characteristics, moreover, which vary with circumstances and media. Yet we can point out more than one interesting similarity between certain ones of these species, which seem to discharge quite distinct functions, and hold very unlike stations, in the vast harmony of vital monads. The cells of fruits, when placed in certain conditions, behave, as has been seen, like the cells of brewer's yeast; they both decompose sugar and yield alcohol. We may trace resemblances not less close, as M. Blondeau and M. Pasteur have done, between acetic mycoderms and blood-globules. Both alike serve as carriers of oxygen—the first, for the slow combustion of alcohol; the last, for the slow combustion of the albuminoid matters in animal tissues. It is even likely that there is a principle in mycoderms similar to hemoglobine in the blood-globule, and provided with a special affinity for oxygen. However this may be, comparisons of this kind open a new path for physiology. As that science is definitely summed up in the explanation of existences and processes in the microscopic elements of organs, it is plain that nothing can be more useful to it than the study of these one-celled organisms in which the phenomena are extremely simple, and life is reduced, in a manner, to its primitive factors. It becomes more and more evident that progress in the comprehension of the superior animals is bound, with the very closest ties, to advance in the comprehension of the mechanism of nutrition in the rudimentary units of life, in the smallest beings that it is given us to study.

II.

Now, whence come those organized microscopic corpuscles to which, as we have seen, very many of the alterations of organic matter must be attributed? Upon this great problem, opinions at this day are still very contradictory. Neither patient observations, nor minute experiments, nor profound reasonings, have been wanting; yet some still believe that these little bodies grow, by spontaneous generation, within fermentable liquids, while others assert, and profess to have proved, that they come from germs contained in the air. Certainly, the former opinion involves nothing contradictory nor impossible. Those who reject it by begging the question, in the name of some unknown, mystical doctrine of life, do not even deserve to be listened to in the investigation. It might possibly have occurred that organized beings should be produced, complete at all points, in a medium deprived of organization; yet experiment proves that this does not occur. We must, then, accept the other opinion—the panspermist doctrine—that is to say, we must concede that the germs of microscopic animals and vegetables, with which so many fermentations and putrefactions are connected, exist in the air. This is one of the conclusions, and perhaps the most legitimate and most fertile one, of M. Pasteur's striking studies.

He deserves the glory of it precisely because he has not priority in it. In truth, the originator of this idea only had, and could only have, a dim intuition of it. He could measure neither its importance nor its consequences. The importance and the results of a great idea, whatever it may be, only become apparent when, after undergoing a certain evolution, it has gained the precision, certitude, and establishment, that nothing but long experience can confer upon it. A conception must have acquired some age in science to wear a fixed authority, and bestow fame on those who comprehend, and cause to be comprehended, all its grandeur and power. The circulation of the blood had long been seen by glimpses, in the schools of physiology, when Harvey gave it complete and vigorous demonstration. Gravitation had long invited research, and suggested presentiment, before Newton drew its perfect system. So, too, the panspermist theory, neglected and ignored since the time of its earliest authors—among whom Astier, in 1813, deserves particular mention—has only been definitely established in our time, through the experiments made by M. Pasteur. These experiments, repeated and varied in a thousand ways, all refer to the investigation, by comparison of what takes place in the same fermentable liquid, under the different conditions of exposure to common air, filled with dust, and of contact with purified air. For instance, M. Pasteur puts a certain quantity of a liquid, that readily undergoes change, into glass balls through which a current of air may be made to pass. Fermentation and the development of small organisms take place very soon in the balls through which common air circulates; but, if the air, before entering them, passes through a plug of cotton, no change in the liquid is observed. When the volume of air, thus filtered through cotton, is considerable, the plug is so filled with dust as to turn black. Now, this dust, in addition to a quantity of mineral particles, and fluff of many kinds, contains spores and germs of fermenting substance, as is proved by the fact that the smallest quantity of it, sprinkled in pure liquid, will produce fermentation in it. An experiment of another kind is this: M. Pasteur, by an ingenious arrangement, inserts and withdraws from a glass jar, filled with pure air, the juice from the inside of a single grape, so that, during the experiment, the juice communicates neither with the surface of the grape nor with the atmospheric air. The juice, thus obtained, shows no trace of fermentation, remaining unchanged as long as the jar is closed; but, if it is opened, or if its contents are mixed with a few drops of water in which the surface of the grape has been washed, fermentation is set up in it at once. This is because the outside of grapes is always covered with yeast-germs, even when the bunches have been subjected to constant rains. In this case, plainly, fermentation is due to the germs suspended in the air, or deposited on the surface of the grapes and stems. M. Pasteur draws blood from an animal's veins by a similar process, and introduces it into a glass vessel in contact with pure air. The blood continues fresh for years. M. Pasteur asserts and proves by experiment that grape-juice, milk, blood, and all liquids that most readily undergo change in ordinary conditions, are incapable of fermentation in air which is pure, that is to say, deprived of the corpuscles it contained.

M. Pasteur has made still another set of experiments. He has obtained development of fermentation in liquids freed from albuminoid substances. It was supposed, before his researches, that the cells remarked in the fermentation of grape-juice proceed from the conversion of the albuminoid substances which this fluid contains in its natural state. M. Pasteur prepares a solution of sugar, tartrate of ammonia, and some other salts, and sprinkles a few yeast-globules in it. They swell, develop, and propagate in this artificial medium quite as well as in the grape-juice. So it was supposed that in the acid fermentation of milk the ferment is a product of the conversion of casein. M. Pasteur proves that supposition to be unfounded, by artificially producing the lactic ferment in a compounded liquid containing not a trace of casein. These very delicate experiments have not only increased the vogue of the panspermic theory, but they have been of great value also to vegetable physiology.

Many objections have been raised to these theories on the origin of ferments, to which M. Pasteur has almost always replied by unquestionable facts and solid reasonings, though he has sometimes done himself the injustice to be rough and contemptuous in discussion toward his opponents. Truth is strong enough to indulge charity for error. The gravest of these objections, it must be said, have applied to problems which do not concern the very foundation of the dispute between the panspermist system and its opposite. For instance, M. Trécul, the skillful and noted micrographer, M. Béchamp, and others, have proved that M. Pasteur mistakes with regard to the evolutions and transformations undergone by microscopic beings in fermenting media. M. Pasteur has certainly made more than one mistake on this subject, and there probably does exist between certain ferment-corpuscles a closer relationship than is supposed at the laboratory of the Normal School; but that does not in the least alter the fundamental character of the theory. Attention is also called to the fact that corpuscles with a determinate structure can be produced complete, without germs, in some liquids. No doubt this is true, but only on condition that the liquids are living ones. No doubt the cambium of vegetables, the blastema of animals, and generally all protoplasmic fluids, are fertile hatching-fields for the spontaneous development of the cells and fibres of living tissues. It is thus that the first elements of the embryo show themselves in the animal ovule. And in this respect the labors of Robin, Trécul, Onimus, Legros, and a great number of other observers, are decisive; but life is the property of these protoplasms; they depend upon an organized system. In the depths of the organism, and shielded from the air, they toil at the creation of microscopic corpuscles. Place them in contact with purified air, in M. Pasteur's glass globes, and then they would be barren.

The last objection M. Pasteur has to meet is, that, if the germs of all these microscopic vegetable and animal lives are in the atmosphere, they should be discovered and recognized there. But, in examining the dust of the air microscopically, we do not by any means detect all the rudiments of that infinitely minute flora and fauna whose existence is attested by the fermentations and putrefactions of organic matter. M. Pasteur has thus far met this argument only by the evidence of his experiments which prove that, in contact with purified air, neither fermentations nor putrefactions are possible. That is strictly sufficient, but we can go farther. It is by no means a sure conclusion that these germs do not exist, because many of them are invisible under the lens. To begin with, we do note with certainty a certain number of species in atmospheric dust. It is therefore an admissible presumption that, if the remaining ones elude our eyes and our microscopes, that merely proves them to be smaller than the observed ones. But, perhaps, the problem ought to be viewed in a different way. We believe that these visible germs are the exceptions, that is, that they are beings already arrived at a certain degree of development, and that, in reality, all true germs are of dimensions forever beyond the reach of microscopic observation, even conceiving lenses to be immensely more powerful than they now are. The microscope barely brings within our range of vision points that measure at least a ten thousandth part of a millimetre. The primitive germs of life cannot even approach the millionth part of a millimetre. Physics and metaphysics both assure us that we must here give up the hope of measuring and estimating things according to the powers of our limited senses. An effort is needed to pursue with the mind's eye these perpetually-dwindling dimensions, still to go on though the imagination fails in the task, and to realize at last how far removed are the bounds of the microcosm. If the faculty of reaching out beyond the limits of our nature, which is one of the noblest prerogatives of our intelligence, does not desert us, we attain to the idea of the vital monads of Leibnitz, the organic molecules of Buffon, the comprehension of existence for primal organisms diffused throughout the world by myriads of myriads, and the conception of the infinitely minute within the infinitely minute.

Thus, just as the infinite universe through which the spheres roll is filled with invisible particles of a subtile matter to which physicists and astronomers give the name of ether, and which supplies the only key to cosmic phenomena, the finite universe in which organization unfolds itself is thronged with corpuscles no less invisible, forming what the illustrious Ehrenberg calls the milky-way of lower organisms, and no less essential for explanation of the processes of which we have traced the general course. As there is an ether wanting in life, so there is an ether endowed with life—a vital ether. Both are above denial; they surpass our reason, yet reason cannot but demand them. They elude the close grasp of experiment, yet experiment does not permit them to be avoided; they are unseen, and without them there could be nothing seen. The mind clings to them with the stress of all its power to embrace, perhaps because it feels a secret, mysterious affinity with them, perhaps because it is in substance of the same essence with them.

III.

Our atmosphere, then, is the receptacle for myriads of germs of microscopic beings, which play an important part in the organized world. Penetrating agents of decay, baneful toilers for disease, they lie ever in wait for the chance to pierce the internal machinery of animals and plants, and create slight or grave disturbances within it. Life often resists or escapes them, but nothing can contest with them its deserted vesture. The corpse is their natural aliment, and death their chosen laboratory. There these lowest of created things work out their lofty destiny in the eternal drama of renewal of organic existences.

When the thin pellicle covering sweet fruits is torn at any point, an opening is made for atmospheric germs. Fermenting cells pierce the interior of the fruit, and produce within it fermentation of the sugar, that is to say, the formation of a little alcohol; and this in its turn is susceptible of the passage into acetic fermentation, giving the pulp an acid taste. At last the pulp itself is destroyed by various fungous growths. When a fruit decays and takes a more or less unpleasant flavor, this depends on the intervention of ferment-cells of atmospheric origin, and on the production of acid or alcoholic substances. An able micrographist, M. Engel, who has lately studied these phenomena minutely, discovers that the yeast-cells which thus produce alcoholic fermentation in the juices of fruits present some slight differences in various fruits, neither do they have the same morphological character as those of grape-must or beer-wort. Varieties occur in these cases, corresponding to the different media in which the nutrition of the little fungus takes place.

The microscopic fungi of the atmosphere play as interesting a part in the alteration of wines. These grow acid, change, become filmy or oily, or take on besides a decided bitterness. All these sicknesses depend on the development of different little plants recognized and described by M. Pasteur; and this scientist, not stopping at the solution of the nature of these disorders, has sought the means of preventing them. Resting on some former observations by D'Appert, he conceived the idea of subjecting wines to the action of a very high degree of heat, so as to destroy the yeast-germs. There was no possibility of doubt as to the destruction of these germs and the prevention of any further change, but it might well be asked whether the delicacy and bouquet of certain wines would not be endangered by the effects of heating. Long-continued experiments prove not only that heating is an excellent method for preventing sickness in wines, but also that, instead of impairing their exquisite qualities, it ripens and strengthens them. The recorded minutes of tastings officially performed during the past year by several members of the syndical wine commission, at the suggestion of M. Pasteur, contain decisive testimony on this point. Fine Burgundy wines, heated in bottle seven years ago to temperatures varying between 131° and 149°, appeared, at the end of that time, superior to the same wines not so treated. Persons who spoke with some authority, M. Pasteur says, declared that heating would in time deprive the wine of its color. The contrary is the case, when the air is excluded during the process; the color grows livelier by heating. It was said that heating would in time alter the bouquet of fine wines, giving them dryness and too great age. On the contrary, the bouquet seems to be heightened with the lapse of time, more positively than with wines not heated. In the case of chambertin and volnay particularly, the tasters noticed this fact. M. Pasteur was led by these studies to investigate the cause of the aging of wines, and he discovered that the phenomenon was due to slow oxidation. Wine kept in glass tubes completely filled and closely sealed does not age. By increasing and regulating the aëration of wine, and particularly combining it with heating, he succeeded in manufacturing in one month excellent old wine. In short, oxygen and heat, acting on wine in certain proportions, promote instead of hindering the development of those volatile principles to which the liquid owes its perfume and part of its flavor; but this discovery is additional to those sought. What M. Pasteur did chiefly look for and did find, in giving exact and methodical rules for heating wines, is a process, applicable on a great scale, for preventing the diseases from which the common vineyard products so often suffer, and that fortunate application is a result from his researches on fermentation generally. In the same way, in consequence of the examinations he undertook as to the share of microscopic organisms in the diseases of silk-worms, he was led to prescribe a practical way of hindering the development of these organisms, and thus preventing the malady.

When we inject into the subcutaneous cellular tissue of a living animal a putrefied or septic liquid, that is, one containing those thread-like corpuscles known by the name of vibrios and bacteria, it sometimes happens that the animal experiences no inconvenience. Dogs particularly resist with vigor the poisonous influence of such a fluid, but the case is different with other species, and notably with rabbits. The system becomes the seat of grave phenomena, almost always mortal, of which the general group composes the affection known by the term *septicæmia.* The microscopic organisms in such a case poison the animal, not only by the mere fact of their presence in the blood, but besides and especially because they develop and propagate in it with astonishing rapidity, in the same way that yeast reproduces itself in barley-wort. But the most singular thing in these pathological fermentations is the fact noted some years ago for the first time by MM. Coze and Feltz, and the study of which M. Davaine took up last year. Davaine demonstrates, by experiments made on rabbits and Guinea-pigs, that one drop of blood, from an animal affected with septicæmia, has the power of imparting the infection to another animal inoculated with it; that a drop taken from the second can transmit the disease to a third, and so on. Still more, very wonderfully, the poisoning power of the blood of these animals increases with the degree of advance in the series of inoculations. The culture of the virus heightens its maleficent properties. This gradual increase of the virulent force is such that, if we take a drop of blood from an animal representing the twenty-fifth term in a series of successive inoculations, and so dilute this drop with water that a drop of the dilution corresponds to one trillionth of the original drop, we get a liquid of which the smallest quantity still displays mortal activity. These experiments of M. Davaine, which exhibit the degree of venom as increasing in an inverse ratio to the apparent quantity of the poison, have been repeated and confirmed by several eminent physiologists, among others by M. Bouley, and have produced a sensation which still continues in the schools of physiology and medicine. Apart from the inherent difficulty of forming a notion as to the influence of those infinitesimal doses, they seemed to yield an argument of a kind to support the assertions of homœopathy. If the difficulty is real, though it may be got over, the argument, we take leave to say, is worthless. Let us look at the difficulty first. This drop which is still mortal, though representing only an infinitely small fraction of the original quantity of poisonous matter to which it is distantly related, permits no corpuscle to be detected. That is true, yet it contains the germs of them, and germs such in number, size, and reproductive power, that nothing prevents them from breeding again indefinitely, in spite of all efforts tried to get rid of them. The discussions that have just occurred in the Academy of Medicine on this grave subject, almost at the same time that the question of ferments was under debate in the Academy of Sciences, leave no doubt as to the reality of this progressive breeding of virulent germs by culture. But is this any argument for the homœopathists? None whatever. They attribute curative effects to extremely small doses of certain inorganic substances most evidently inert, which can in no way reproduce themselves. If the virulent elements occasion disturbances so profound in animal organisms, it is not by reason of their extreme minuteness, but it is because they multiply with prodigious rapidity in the depths of the tissues and humors, where they labor in a manner opposed to the harmonious life of the body.

However this may be, the vibrios and bacteria have an undeniable share in the production of human maladies. They are found in the blood of persons attacked by infectious disorders, and if in many cases their relation to these disorders is only that of concomitants, in others, their relation of causality is very clearly ascertained. Thus M. Davaine's investigations prove that the maladies called carbuncular, so formidable in men and animals, are due to the excessive development of a species of bacteria in the blood. Typhoid fever also seems to acknowledge a cause of the same kind. Rabbits die from inoculation with blood taken from men attacked by this disease. Our knowledge upon this difficult subject, it must be owned, is very little advanced, in spite of the ardent labors devoted to its extension in the past few years. The illusions of the microscope and the exaggerations of a spirit of routine too often impair the value of studies undertaken in this direction. Without going so far as does the opinion of those who attribute all these disorders to microscopic corpuscles, and regard all morbid phenomena as fermentations, it must at any rate be admitted that these corpuscles, diffused throughout the air, take an important place among the eternal enemies of health. At all times surgeons and physicians have recognized the danger from penetration of common air into the interior of the organism, by the way of wounds or otherwise. We now understand the explanation of the danger. It is not the gases of the air that are dangerous; but the proto-organisms contained in that fluid must be charged with the fatal influence it exerts in traumatic cases, and putrid infection has no other origin. Thus the anxiety of practitioners now is to protect wounds from access by the germs in the air, by means either of impermeable coating, or of antiseptic dressings, containing alcohol or phenic acid, or by pneumatic closing up, or by filtration of the air itself through cotton. Under the influence of ideas distinctly introduced into science by the researches we have just reviewed, several practices in surgery have undergone great modifications.

After examining the alterations produced in the living, we have to consider those occasioned by fermentations in the dead. When life has retreated by slow degrees from all the parts of an organized being; when, after all partial deaths have occurred, total death has possessed the depths of the subject, and broken all the springs of its activity, the work of putrefaction begins. Its task is to unmake this body, to destroy its forms, and dissever its materials. The work to be done is to disorganize it, to reduce it into solids, liquids, and gases, fit to go back again into the vast reservoir whence new life is incessantly issuing. This is the task that heat, moisture, air, and germs, will undertake in unison. It is all performed with steady diligence. Nature knows no delays; as soon as the body is cold, the protecting coating that covers all its surface, the epithelium, decays in places, particularly in the moister parts. The agents of disorganization, vibrios and bacteria, or rather the germs of these thread-like corpuscles, penetrate through the skin, wind into the small ducts, invade the whole blood, and by degrees all the organs. Soon they swarm everywhere, almost as numerous as the chemical molecules in the midst of which they stir and circle. The albuminoid matters are decomposed into fetid gases, escaping into the air. The fixed salts, alkaline and earthy-alkaline, slowly release themselves from the organic matters with which they combined to form the tissues. The fats oxidize, and grow acrid; the moisture dries away. Every thing volatile vanishes, and, at the end of a certain time, nothing remains save the skeleton, but a formless mingling of mineral principles, a sort of humus, ready to manure the earth. Now, all these complex operations absolutely required the intervention of the infusoria of putrefaction. In pure air, deprived of living germs, they could not have been accomplished. To check putrid fermentations, to insure the conservation of animal or vegetable substances in a state of perfect integrity, only one means avails, but that is an infallible one—that of thoroughly precluding the access to them of the aërial germs of vibrios and bacteria. Whether we adopt D'Appert's method and begin by subjecting these substances to the action of high temperature, preserving them after that in hermetically-closed vessels; or whether, as we have seen very lately practised by M. Boussingault, we introduce them into an extremely cold medium; or whether we saturate them with such salts as have antiseptic properties, in every case they are protected from putrefaction by paralyzing the effect of the lower organisms. The corruption of animals is not more possible than the fermentation of grape-juice, barley-wort, milk, etc., when it is made impossible for the germs to act. This is another fact demonstrated by M. Pasteur.

We have just used the term antiseptic, that is, capable of destroying germs, and preventing the action of ferments. The interest connected with such substances is easily understood. In truth, they are at the present time the chief objective point of therapeutic researches. At the same time that chemists and physiologists are engaged with persevering zeal in studying the functions of microscopic corpuscles in living Nature, physicians, perceiving their manifold and baneful activity in the production of disease, are seeking the means of reaching and destroying them. Every one knows those principles, like phenic acid, which are extracted from pitch, and are also found in smoke, to which they impart antiseptic properties that have been utilized from time immemorial. Other substances have been lately discovered, not less remarkable for their energetic resistance to fermentation and virus. Among the number are the alkaline sulphites and hyposulphites, which have been the object of very interesting examination on the part of an Italian physician, M. Polli; the borates and silicates of potassa and soda, to which M. Dumas invited the attention of physiologists a year ago; the acetate of potassa, and others. Hitherto the physiological virtues of active principles have been studied only with respect to the higher order of animals: M. Dumas pointed out the great interest there would be in examining the influence they exert over the lower organisms charged with the elaboration of ferments, and over ferments themselves. Such researches not only contribute to a better knowledge of the mechanism itself according to which these principles affect the system of vital phenomena, but they also gain the most useful indications for the healing art. Indeed, beginning with the moment at which M. Dumas and other chemists made known the result of their examinations on this subject, coincident also in time with the experiments of M. Davaine on septicæmia, a vast number of attempts were entered upon, in hospitals and in laboratories, to discover to what extent these anti-fermenting substances hinder morbid fermentations. These attempts are still proceeding; we cannot foretell their success, but we are authorized even now to say that they will not be barren of advantage to the healing art. In this, as in all other departments of scientific activity, we see abstract studies result in useful discoveries.

As a general statement of the subject, all this immense work of fermentations, putrefactions, and corruptions of organic matter, is effected in the world by a small number of species of microscopic cells and filaments, by fungi and spores of the lowest order, of which the germs fill our atmosphere. This is one of the most certain acquisitions of modern science, one of the most important from the point of view of natural philosophy, one of the most productive for those arts that are concerned in improving the condition of mankind. We may now regard it as firmly established; but let us not forget that its establishment has cost two centuries of investigations and labors. Leuwenhoek, in the middle of the seventeenth century, was the first to reveal the microscopic world of the air, and to conjecture its momentous functions. What severe toil, what struggles and tedious trials, since the observations of the Dutch micrograph, to the time of the experimental studies of our contemporary and compatriot, M. Pasteur!

BIRDS-OF-PARADISE.

By JAMES H. PARTRIDGE.

THE Birds-of-Paradise are a small, but renowned family. They received their name from the idea, entertained at one time, that they inhabited the region of the Mosaic paradise. They live in a small locality in Australasia, including Papua or New Guinea, and a few adjacent islands. They are not easily tamed and kept confined; and few have been brought alive from their native locality. Mr. Beale had one at Macao, China, that had been in captivity nine years; several have been kept at Amboyna, but very few have ever been carried to Europe, although specimens of the skins and prepared birds were taken there more than 300 years ago. Anthony Pigafetta, one of the companions of Magellan, first imported them into Europe in 1522.

In form and size they somewhat resemble our crow, or blue-jay; but some are smaller. They are usually included in the tribe of cone-bills, though their bills are quite slender for that group, and a little compressed. The bills are covered at the base with downy or velvety feathers, which extend over the nostrils: their wings are long and round; the tail consists of ten feathers, two of them, in some species, very long; legs and feet very long, large, and strong; outer toe longer than inner, and joined to the middle one toward the base; hind-toe very long; claws long and curved. But they are chiefly remarkable for the wonderful development of various parts of their plumage, and for the metallic splendor of its rich hues. The sides of the body, and sometimes of the head, neck, breast, or tail, are ornamented with lengthened, peculiarly developed, and showy feathers. Says Wood: "In all the species, the feathers glow with resplendent radiance; in nearly all there is some strange and altogether unique arrangement of the plumage; and, in many, the feathers are modified into plumes, ribbons, and streamers, that produce the most surprising and lovely effects." The plumage of the face, breast, and throat, is usually the richest in metallic tints, while other parts frequently have very beautiful and brilliant colors.

Their food consists of grasshoppers, butterflies, moths, and other insects; figs, the berries of various trees and shrubs; seeds, rice, and other kinds of grain. During the heat of the day they remain concealed in the woods, but, in the morning and evening, come forth to seek their food. Furious storms frequently bring them to the ground, when they are easily taken by the natives, who also shoot them with blunt arrows, or take them with a noose, likewise with bird-lime, or other glutinous substance, placed on the branches which they frequent. They sometimes stupefy them with *cocculus indicus.* Europeans shoot them with shot-guns. The natives formerly skinned the birds, cut off the legs and wings, and dried the skin on a stick. Later they took out the interior organs of the bird, cut off the legs, and smoked the birds with sulphur, or seared them inside with a hot iron; and, after being thoroughly dried, they put them in the hollow of a bamboo, to secure the plumage from injury. They are used by the natives, the Japanese, Chinese, East Indians, and Persians, for adorning the turbans of the men, the head-dresses of the women, and for various other purposes of ornament. The Chinese make imitations of these birds from the feathers of parrots and paroquets, to sell to strangers. The feathers were formerly, and are still, used very much as ostrich-feathers are. By their lightness and lustre, they are extremely well suited for the ornaments of dress, and are very highly prized. In Europe and America, at the present time, they are sought for with avidity, to adorn ladies' hats, etc. The birds and feathers for the European market are principally obtained at Batavia and Singapore, whither the natives of Celebes, and others, bring them from Papua and the

Fig. 1.

Greater Paradise-Bird (*Paradisea apoda*).

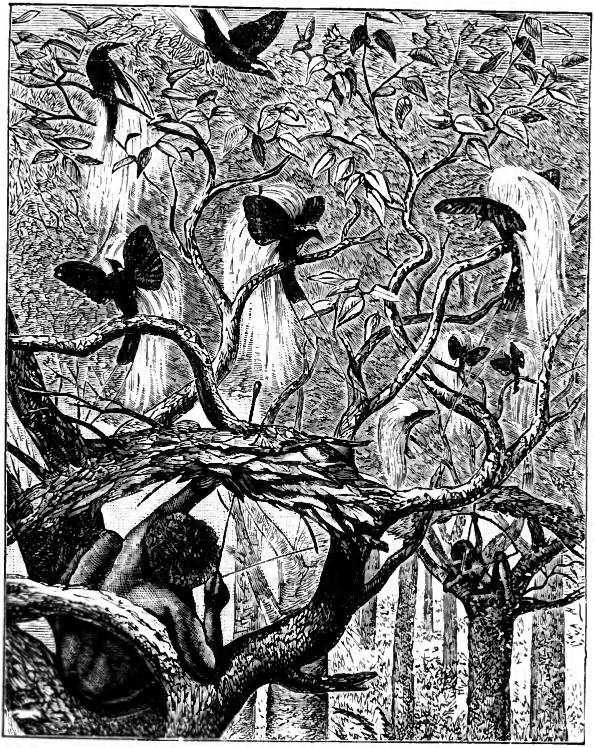
Arroo Islands. In India they derive much of their value from the miraculous virtues which the priests have ascribed to them, causing the creature that produced them to receive the title "Bird of God," *Manuco-Dewata*; from which Buffon coined the modern French name, *Manucode*. Dr. Forster suggests, but perhaps without reason, that this bird may have been the phœnix of antiquity.

During the dry weather of the northwestern monsoon, in our autumn and winter, many of the birds leave Papua and go west to the Arroo group; but, upon the commencement of the wet weather of the southeastern monsoon, in our spring, they immediately return to Papua. They usually fly, on these occasions, in flocks of thirty or forty, with a reputed leader. Their moulting-time is from May to August, during the southeastern monsoon. On account of the difficulty of managing their enormously-lengthened, gossamer-like plumage, they usually face the wind, whether flying or sitting. In proceeding from one place to another, they are often distressed by sudden shiftings of the wind; and, being unable to proceed in their flight against it, or go with safety before it, they are sometimes thrown to the ground. In tempestuous weather they seek the most sheltered retreats of the thickest woods. Although very active and sprightly, they are exceedingly shy and retiring in their habits. The false ideas that they were footless, lived ever on the wing, or occasionally rested suspended by the tail; fed on the dew; reared their young on the shoulders of the male, and came from the terrestrial paradise, have all had their day, but are too absurd to be more than alluded to now.

The Greater Paradise-Bird (*Paradisea apoda*), frequently called the Emerald Bird of Paradise, is smaller than the crow. Linnæus gave the specific name *apoda* to this bird, which was generally and erroneously called footless, to designate the species, not to perpetuate the error. This bird seeks the thickest foliage of the loftiest trees, in which to remain concealed during the day. The feathers on the head, throat, and neck, are very short and dense. Those round the base of the bill, and on the face, are velvety and black, changing their color to green, as the direction of the light changes; those on the throat, the front half of the neck, and the upper part of the breast, are of a bright, deep, emerald green; those on the head, back of the neck, and the shoulders, are of a light, golden yellow. The eye is at the common point between these colors. If lines were drawn from it to the throat, to the forehead, and down the sides of the neck, and curved to a point on the breast, they would indicate very well the limits of the colors. The back, wings, tail, and belly, are of a bright, reddish chestnut, the breast being a little darker, and inclining to purple. From each side beneath the wings proceed a large number of long, floating, graceful plumes, some eighteen inches in length, of exceeding delicacy of texture and appearance. These extend far beyond the tail-feathers, which are about six inches long, and "their translucent golden-white vanelets produce a most superb effect, as they cross and recross each other, forming every imaginable shade of white, gold, and orange, and then deepening toward their extremities into a soft, purplish red." From the upper part of the tail proceed two black shafts or filaments, some eighteen inches long, appearing like small wires, about one-sixteenth of an inch in diameter. The female has no floating plumes, no gem-like feathers, and no brilliant colors. The head is dark-brown; the neck, light-brown; the upper parts of the body, wings, and tail, reddish chestnut; the breast and belly, white.

In Bennett's "Wanderings" is an interesting description of Mr. Beale's bird, at Macao. The writer says: "This elegant creature has

Fig. 2.



Natives of Arroo shooting the Great Bird-of-Paradise.

a light, playful, and graceful manner, with an arch and impudent look; dances about when a visitor approaches the cage, and seems delighted at being made an object of admiration. Its notes are very peculiar, resembling the cawing of a raven; but its tones are, by far, more varied. It washes itself regularly, twice daily, and, after having performed its ablutions, throws its delicate feathers up, nearly over the head, the quills of which feathers have a peculiar structure, so as to enable the bird to effect this object. Its food, during confinement, is boiled rice, mixed up with soft eggs, together with plantains, and living insects of the grasshopper tribe; these insects, when thrown to him, the bird contrives to catch in his beak with great celerity; but, if, through failure to catch them, they should fall to the floor, he will not descend to them, appearing to be fearful that, in so doing, he would soil his delicate plumage; he will eat insects in a living state, but will not touch them when dead. One of the best opportunities of seeing this splendid bird, in all its beauty of actions, as well as display of plumage, is early in the morning, when he makes his toilet; the beautiful sub-alar plumage is then thrown out and cleaned from any spot that may sully its purity, by being passed gently through

Fig. 3.

Red Bird-of-Paradise (*Paradisea rubra*).

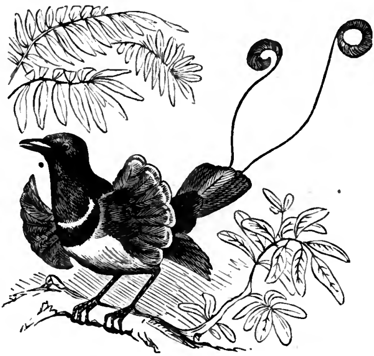
the bill; the short, chocolate-colored wings are extended to the utmost, and he keeps them in a steady, flapping motion, as if in imitation of their use in flight, at the same time raising up the delicate, long feathers over the back, which are spread in a chaste and elegant manner, floating like films in the ambient air. In this position the bird would remain for a short time, seemingly proud of its heavenly beauty, and in raptures of delight with its most enchanting self; it will then assume various attitudes, so as to regard its plumage in every direction. Having completed his toilet, he utters the usual cawing notes, at the same time looking archly at the spectators, as if ready to receive all the admiration that it considers its elegant form and display of plumage demand. It then takes exercise by hopping in a rapid but graceful manner from one end of the upper perch to the other, and descends suddenly upon the second perch, close to the bars of the cage, looking out for the grasshoppers, which it is accustomed to receive about this time."

Vanity and egotism, as usually developed, are exceedingly offensive and distasteful; but when we see a delicate creature, so richly embellished, so neat and cleanly in its habits, so fastidious in its tastes, so scrupulously exact in its observances, and so winning in all its ways, as to etherealize the commonest actions, they become not only endurable, but amusing, and even enjoyable. And if a bird, in a state of hopeless captivity, exhibits such marked traits of character, acts out so truthfully the promptings of its nature, shows so evidently its desire to please, and possesses so nice an appreciation of being admired, how perfect must be all its ways and actions, as developed in the pure, bright air, fragrant groves, and luxuriant surroundings of its native haunts!

The Red Bird-of-Paradise (*Paradisea rubra*, Vieillot) is about as large as the preceding, and in many respects resembles it. The feathers on the head and neck are short and dense. Those around the bill, on the face, and top of the head, including the two crests, are velvety and black, appearing green when viewed in a different direction; those on the throat and front half of the neck are of a bright, deep green; those on the shoulders, upper wing-coverts, back of the neck, and across the upper part of the breast, are of a golden yellow. Lines drawn from the eye to the throat, to the back of the head, and down the sides of the neck, and curved to a point at its lower part in front, would nearly coincide with the limits of the colors. The wings, tail, and belly, are of a deep chocolate-brown; the breast being of a little darker color. From each side below the shoulder proceeds a tuft of loose, plumy feathers, about a foot long, of a beautiful, deep carmine color, slightly tipped with white. From the upper part of the tail arise two black, slender, ribbon-like shafts, about two feet long, and nearly one-fourth of an inch wide, without any web, and toward the end inclining to curl.

The King Bird-of-Paradise (*Cicinnurus regius*, Linnæus), called by the Papuans *Saya*, is about as large as the thrush; but the male bird has a tail so short as to give it a jaunty appearance. It is not fond of tall trees, but keeps mostly among the small bushes, seeking berries and other food. It is a solitary bird, and very beautiful. As it is sometimes found with other species of the same family, and yet keeps somewhat aloof from them, it was formerly supposed to be their leader. The head, neck, upper part of the breast, the back, wings, and tail, are all of a deep red or maroon color, the head inclining to orange, and the breast to a darker red. The belly is white. Across the chest there is a band of beautiful green feathers, that, in some directions, appear black. From each side beneath the shoulder arises a tuft of broad, truncated, light-gray feathers, or plumes, two or three inches

Fig. 4.



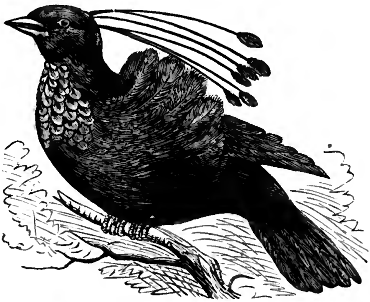
King Bird-of-Paradise (*Cicinnurus regius*).

long, tipped with bright metallic green. From the middle of the tail or upper-tail coverts proceed two shafts or filaments, appearing like wires, about one-sixteenth of an inch thick, naked for about six inches, then having a bright, golden-green web on the inner side of each shaft to the end, each of which is there coiled outward in a spiral curve, so as to form a beautiful flat disk; the shaft extending nearly twice round the curve. This peculiarity gives to the bird its generic name, *cicinnurus*, meaning a tail with curled feathers: its supposed leadership gave to it its specific name. Most parts of the bird have an exceedingly brilliant, satin-like gloss. The female is of a dull-brown color above; gray, streaked with black, beneath; tinged with red on the wings; and has a tail about three inches long.

The Gold-breasted Bird-of-Paradise (*Parotia sexpennis*, Vieillot) has three long, slender shafts, or feathers, proceeding from each side of the head near the ear; they being without web, except the part near the outer end. These can be raised or lowered at pleasure, so as to stand out horizontally on each side of the head, or left to hang loosely backward. It has also a small crest. From each side beneath the shoulders arise massive black plumes, with a loose web, like that of ostrich-feathers. The general color of the bird is a deep, velvety black; the head, throat, and back, having a violet gloss; the wings and tail, black. The neck and breast have scale-like feathers of a brilliant, changeable green, edged with gold.

The Superb Bird-of-Paradise (*Lophorina atra*, Vieillot) is distinguished for its black, velvety scapulary feathers, which are greatly developed so as to form a long, double tuft or plume, which it can raise at pleasure, so as to appear as a very large, double crest, or permit it to fall upon its back and sides. A tuft of feathers, also, hangs

Fig. 5.



Gold-breasted Bird-of-Paradise (*Parotia sexpennis*).

from the breast, which spreads "into a doubly-pointed form, being of the most brilliant steely green, and glittering with gem-like radiance in the sunbeams. The general color of the bird's plumage is the deepest imaginable violet, appearing of a velvety blackness from its very intensity, and only flashing forth in the brighter hues as the light falls upon the edge of each feather. The back, hind neck, and head, are of a greenish-gold color, with a velvety appearance; the wings are a dull, deep black; the tail is black, with a blue gloss; the throat, changeable violet; and the belly, bright golden green."

Wallace's Bird-of-Paradise, or the standard-wing (*Semioptera Wallacei*, Gray) is a little larger than the American robin. The head, neck, back, wings, and tail, are all of a light brown or drab color; the belly, drab streaked or mottled with black. From the short feathers at the bend of each wing arise two white feathers or plumes, about six inches long, which the bird can raise and keep erect, or let fall upon the wing, at its pleasure. But the great beauty of the bird consists in its brilliant double tuft, proceeding from the breast and lower part of the neck, extending downward and obliquely outward, and terminating in two points about four inches apart. This tuft is of a bright, metallic green, changing into blue, violet, or black, according to the direction of the light; it is exquisitely beautiful in itself, and its beauty is increased, if possible, by the striking contrast with the otherwise dull color of the bird. The legs and feet are of a drab-color. The female is wholly of a drab-color, without tuft or wing-shafts.

The Magnificent Bird-of-Paradise (*Diphyllodes speciosa*, Boddaert) is about as large as a thrush. The head, back, tail, and primary wing-feathers, are dark-brown; the other wing-feathers, yellowish-brown. The breast and belly are of a beautiful purplish green. A circular tuft extends over the hind-neck and shoulders, and is, in the upper part, light yellow, and in the lower parts brown; this double tuft, on account of its resemblance to leaves, gives to the bird its generic name. The tail is about two inches long, and from its upper part arise two thread-like feathers about ten inches in length, each coiled in a circle about three inches in diameter. The shafts of these feathers have, on one side, a narrow web about one-sixteenth of an inch wide, of a beautiful green or violet tint, according to the direction of the light.

FIG. 6.

SUPERB BIRD-OF-PARADISE (*Lophorina atra*).

The Long-tailed Paradise-Bird (*Epimachus magnus*) has a tail more than two feet long. It is sometimes called the Superb Plume-Bird, and, with the next species, is included in the same family as the hoopoes. It is a native of New Guinea, and is a most beautiful and lovely creature. Lesson says: "To add to the singularity of this bird, Nature has placed above and below its wings feathers of an extraordinary form, and such as one does not see in other birds; she seems, moreover, to have pleased herself in painting this being, already so singular, with her most brilliant colors. The head, neck, and belly, are glittering green; the feathers which cover these parts possess the lustre and softness of velvet to the eye and touch; the back is changeable violet; the wings are of the same color, and appear, according to the lights in which they are held, blue, violet, or deep black, always, however, imitating velvet. The tail is composed of twelve feathers; the two middle feathers are the longest, and the lateral feathers gradually diminish; it is violet or changeable blue above, and black beneath. The feathers which compose it are as wide in proportion as they are long, and shine both above and below with the brilliancy of polished metal. Above the wings, the scapularies are very long and singularly formed; their points being very short

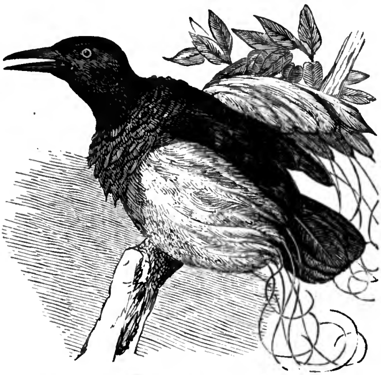
Fig. 7.

Long-tailed Paradise-Bird (*Epimachus magnus*).

on one side, and very long on the other. These feathers are of the color of polished steel, changing into blue, terminated by a large spot of brilliant green. From each side beneath the shoulders spring long, curved feathers, directed upward; these are black on the inside, and brilliant green on the outside. The bill and feet are black."

The Twelve-wired Paradise-Bird, sometimes called the Twelve-thread Epimachus, or Plume-Bird (*Seleucides alba*, Lesson), is a little larger than the jay. It has an elongated body, ample, concave wings, a black beak about two inches, and a tail three inches long; the legs and feet are of a pink-color. it is a native of New Guinea, and is fully as beautiful and lovely as the preceding species. All its plumage has a soft, velvety appearance. The head, neck, and breast, appear black. Across the breast, and on the shoulders, is a circular tuft of black feathers, two or three inches long; those on the sides

Fig. 8.



Twelve-wired Paradise-Bird (*Seleucides alba*).

of the neck being, at the end, of a metallic green. The wings are of a rich violet, with a brilliant lustre, in some directions appearing intensely black. From each side beneath the wings proceed a number of silken, snow-white plumes, whose loose, downy vanelets, are gracefully waved by the gentlest breeze. The contrast between the general velvety or lustrous blackness of the bird and the snowy whiteness of these delicate plumes is exceedingly striking, and produces a most pleasing effect. These plumes are about six inches long; and six of the shafts, on each side, are prolonged about ten inches beyond the extremity of the web, and there appear like black threads or wires, giving to the bird its common name. The parts of these shafts which bear the web are pure white, as well as the web. The feathers of the Plume-Birds are taken to Europe, and used as an ornamental part of dress for ladies.

On the upper floor of the old Arsenal Building (which is open to the public the last four days in the week), in Central Park, New York City, there are several prepared specimens of Birds-of-Paradise, including five Great Birds, three Red Birds, four King-Birds, four Wallace's Birds, one Magnificent Bird, and one Twelve-wired Bird. These specimens will give, to any one who can examine them, a better idea of the size, form, color, and general appearance of the birds; the metallic lustre, change of color, and delicate structure of their plumage, than any words or engravings can convey. They would furnish a definite outline that would much assist and guide the imagination in giving life to their forms, spirit to their actions, and reality to their finer traits of character, as developed in their native islands. But still all lifeless forms fail to come up to the living birds in a state of freedom. And we need not be surprised at the enthusiasm of the amateur, who observes them in all their freshness and beauty, sitting in the aromatic trees, feeding among the bushes, floating in the breeze on their gossamer-like plumes, or glancing through the groves like streaming meteors, in the exhilarating atmosphere of their own genial clime.

THE CHAIN OF SPECIES.

By Hon. LAWRENCE JOHNSON.

Part III.—*The Passage from Annulosa to Mollusca.*

ANOTHER plan, however, is proposed, which seeks to connect Annulosa and Mollusca as successive stages in the progress of evolution from the simplest types and stages necessary to be taken in order to reach the highest development. This is the chain: Evolution of Protozoa directly into Annulosa; or first into the cœlenterate type and these into the annulose, either of which routes seems feasible and easy; then Annulosa into Mollusca; and then Mollusca into Vertebrata. Pursuing this road, the only difficulty of importance is the passage from the articulate or annulose form to the mollusk. Enough has already been said to furnish the key to all the other transitions, and the few brief minutes left us must be devoted to this really obscure problem. If the bridge erected here is practicable, it puts a different aspect upon the whole question, and reflects light backward and forward on every link of the chain.

As remarked, the only real difficulty is to connect annulosa and mollusca. For from cephalopods it is easy to develop the vertebrate type, by elongating the ventral aspect of the creature; and bringing down therewith the ventral portion of the cephalic appendages, which subsequently assume, or rather return to, the place and functions of lateral limbs to the main trunk; the other cephalic appendages, properly belonging to the neurohæmal axis, easily taking the form and offices of œsophagus, branchiæ, and even internal bronchial apparatus. Evolution of *amphioxus*, in this way, from some lost *octopus*, is easier to account for than from *salpidæ*, as proposed by recent authors; even if amphioxus is a vertebrate animal, which is exceedingly doubtful. But the difficulty is to get to cephalopods.

It is confessedly easy to pass from the cœlenterate type to the annulose—or, in the old style, from *Radiata* to *Articulata.*

Nothing is more manifest in Nature than that she never loses the effect of a habit—never gives up a plan—never resigns the use of means and tools once adopted. When we have arrived at the involute cell as the type of the endothentic series—the animal kingdom—nothing is more obvious than the compounding of the simple form to constitute the rest of the kingdom. Nor is it necessary to suppose that the compounding takes place by any other means than that already observed in the case of exothentic creatures. If vegetal cells multiply and compound by a *gemmating* and fissiparous process, so also does the endothentic and celœnterate type.

Mr. Spencer has shown, triumphantly, how this may take place even mechanically. A simple endothen becomes two by ordinary growth, until division is forced at some median point, exactly as in the case of a cell. When the separation is complete we say this is an increase by gemmation. When there is differentiation without separation, we call it *compounding*—or, as Mr. Spencer has it, an aggregation. The same two great laws of aggregation and segregation, which rule in all things else, present themselves here also in explanation of the phenomena of life. As presented in annulose and annuloid creatures, the compounding is a segmentation. For an annulose or articulate segment is nothing else but one of the simple elements of a compound structure, of which the distinction of the parts is less pronounced. In sponges, in corals, in compound ascidians, the segregation is far advanced—the compounding is very evident. In these it is not denied any more than in the analogous compounding displayed in mosses, ferns, and trees. For, according to the laws of vegetal life already reviewed, every leaf, every node, is a distinct creature, and the bud of the node its progeny. But it is not at first sight so obvious that the real law of all creatures constituted of rings and joints is the law of compound association. It is difficult, without some reflection, to admit that every segment in these is a modification of the original unicellular creature—the mono-segmentarian from which the aggregation sprang. Yet the most casual anatomist cannot fail to perceive that each section in annulosa is but a repetition of the same structure with all its organs and appendages. Even where there are modification and differentiation of function, the structure is always and evidently identical—perfectly homologous.

Fully comprehending the nature of segments, we may proceed to the further efforts of Nature to obtain higher combinations and greater concentrations of energy. For this seems to be the end and object aimed at, if we may be allowed in our own minds to clothe Nature with conscious impersonation, i. e., personality. From the organization of the first drop of protoplasm, and the vivification of the first cell, the tendency has been, as the necessary result of natural selection, to concentrate force. In the history of evolution there is no passing from lower to higher forms—no foldings, no involutions, without an increase of power; and by the same law this development must continue until the highest point of physical energy is attained.

Our ordinary discoveries teach us that force can be multiplied by a multiplication of the elements or organs evolving force. The simplest child knows how to obtain two pounds instead of one by putting another weight in the scale; and the electrician obtains more power by adding another jar, or another plate, or another cell to his battery. In like manner Nature has in various directions seized every means to increase and concentrate what for convenience is termed *vital force*. For there is the same tendency of the forces to aggregation that we see in matter.

Watching the progress as we have ascended the scale from the first evolution of life, the greatest concentration of force yet reached in organic life is in articulate creatures—or, as we may call them, by a name of more general application, segmentarians. A segmentary such as a centipede, a bee, a lobster, or even the humblest worm, is as truly a compound zoary as any other collection of zooids, whether cœlenterate or molluscoid; and no argument is needed to show a physicist that the closely-united segmentarian zoary evolves more force than the looser aggregation of a branch of ascidians, however highly organized the individuals of the latter may be. There is more force evolved from the gigantic oak consisting of such a closely-united system as presented by the nodes, and which is capable of appropriating such volumes of inorganic matter, than in the loose sheets of *ulva* or *protococcus* creeping upon damp walls and slimy pools. Again, in physics, we may multiply force, not only by the number of our elements, but by their size and arrangement. In galvanism two large elements or cells may be made to exhibit greater energy than many small ones in the aggregate of equal superficial extent, yet not precisely the same energy. It is modified as well as increased. Organic Nature presents us exactly as good illustrations of this law as the experiments of Mr. Grove and Dr. Faraday.

The first experiment, so to speak, of Nature to multiply force from the cœlenterate or monosegmental creature, the last stage arrived at in our progress, is by multiplying the segments upon one or more axes. When upon more than one, as in annuloida, Nature seems to break down early, on account of the complication of the machinery, and soon seeks greater simplicity. This is attained, first, by selecting one longitudinal axis, and multiplying the units or elements of organization and force indefinitely. In some worms the number of segments is incredible. Instances of iulidæ, according to Mr. Newport, have one hundred and fifty rings, at least during embryonic life; and, by the same rule, some geophilidæ, mentioned by Dr. Carpenter, must reach to three hundred and twenty—each segment, remember, having a *quasi*-separate organization, separate circulation, separate nerves, and separate appendages for aëration and locomotion. Their close and intimate connection does not prevent easy analysis into distinct systems for each segment.

Again, however, Nature soon discovers her mistake. The highest concentration of energy cannot be reached in this way, and she makes trial of a new plan. She seeks to modify and expand the elements, and to bring them into closer contiguity. Gathering up her forces into a few central segments, the rest are lopped off. This is actually the history seen in some embryones. In insects, finally, the highest of the segmentarians, there are only about twenty well-pronounced segments. Some of these, as in the cephalic and thoracic regions, are so intimately united that the divisions cannot be traced, except in the embryo. In adults the thoracic segments are further modified, for great extension and concentration of force, by expansions, primarily, of the aërating apparatus into legs, wings, or other appendages. In short, the thoracic region is evidently the concentration of the life of these creatures.

Now to advance beyond this type. Nature never changes her tools—her means; and even her plans present but slight modifications. Her collection and concentration of energy in the thoracic region of polysegmental annulosa is a gathering of her strength at that point whence the next march will begin.

Exactly as we may see an individual segmentarian zoary doubling itself up for its own comfort, increase of heat, or of force—exactly as we have seen in vegetal life, after a longitudinal or a superficial evolution of the elements of the compound, energy concentrated by a folding down of the compound upon itself, and an adhesion—so works Nature here. The concentration of life or force at any one point diminishes its intensity in remoter segments; a more intimate union of a few segments causes atrophy in the more distant frontier provinces; and this process continues, in fact, until the segments are reduced to two. The very fact of a closer folding and adhesion of two would have this result. This is a position we might, at this stage, comprehend *a priori*. Now let us see if it has any foundation in fact.

Again I repeat, this is not an imaginary process I am going to amuse you with—it is not speculation—but an irrefragable chain of facts and demonstrations. The *entomostracous* group of *crustacea* affords us illustrations of every step of the progress. First, an excessive development of two segments of the thorax; then, atrophy or dwarfing of the cephalic and abdominal regions, in various degrees. In cypris, for instance, two segments are so enormously developed as to usurp the mass of its substance, if not yet all the functions of its life. The dorsal scales of these two segments are actually so enlarged as to present a bivalve box, or case, to inclose the creature as snugly as you see effected for a clam or an oyster. Loss of head and tail would leave the little cypris as perfectly a testacean mollusk as any of these.

But you say, if—if it should lose head and tail! The exaggerated fable of the fairy tale is actually the method adopted by the magician Nature to disenchant the fair princess Life from the thraldom of larval and infusorial forms. The cypris does lose head and tail, and so becomes molluscan, before proceeding to higher evolution. But not as a cypris—oh, no! she changes her name, as she changes her type; and we must advance to another group of the entomostracous class—one which has been divided from it, more on account of general superior size than for any other reason—the *cirrhipeds*.

In this group we find the most striking metamorphoses in the life of the same individual. Passed out of the mere embryo, the larval form resembles more an ordinary macrourous decapod than the entomostracous its nearest relations. Take one generally known, the genus *lepas*—the common goose-barnacle—in extreme youth, an exceedingly active little shrimp-like tenant of the deep. During the latter part of this stage, the hypertrophied segments of the thorax continuing to grow as the cephalic and abdominal parts dwindle, finally, by his jaws, he first seizes hold of some solid support, when the whole head and neck become entirely changed, and remain a mere stipe, for the support of the creature. Every part becomes metamorphosed. The head having disappeared, a new mouth is opened in the breast; and the abdominal portions, although not entirely lost in this genus, are differentiated to other functions. The most important change to notice, in this creature of change, is the change of axis. It is now exactly at right angles to the original axis of vitality in the young crustacean. Yet, mark well: this is only a return to the true axis of nerve-force in the segments, which, in all *annulosa*, is at right angles to the longitudinal development of the sections. The interminable gemmations and addition of segments to the zoary being arrested, and life confined to one or two, most naturally the current of the dominant force remaining controls the direction or axis of all the rest. So completely have the method of vitality and the appearances of the little animal been changed, that earlier naturalists classed the young *lepas* as a crustacean, and the adult barnacle as a multivalve mollusk. And so, indeed, it is a mollusk, with a few crustacean characteristics not yet lost.

The steps from this to the perfect mollusk are too plain to be dwelt on here. Indeed, the difference is so small that, had not the larval cirrhiped been discovered, the position of the group would never have been assailed. They should, like human aspirants to rank, have concealed their plebeian origin. If the observations of recent embryologists are to be credited, many mollusks and molluscoidea exhibit a similar evolution. At any rate, even in undoubted mollusca, the elements of their segmentarian origin are abundantly visible.

If we take the genus *arca*, for instance, as a typical mollusk, it is easy to follow the segments of which it is composed. Each half of this bivalve has its own organization, as complete as in any segment of any annulosa. Each has its own heart, its own nerve-ganglia and branches, its own aërating apparatus and systemic circulation, such as it is. You may even trace, still, the crossing of muscles and nerve-fibres, at the back or hinge, exactly as between the two articulate segments from which they sprang.

Here it may be remarked, again, how tenacious Nature is of her plans. This mysterious crossing and anastomosing of nerve-fibres, so unaccountable in the brain of the higher animals, and of such important consequences even in man himself, had its origin in the primal union of two *annulose segments.*

Having overcome the principal difficulty by noticing the change of axis, nothing more remains but to pursue this bisegmental arrangement to its full development in the grand class of mollusks. Possibly not one of existing species had any part in the chain of development. But this is of small interest at present, since we are looking for the method, the steps, the finger-boards of the road traveled, and care not now to count the milestones.

The transition from the highest mollusca to vertebrata, as already remarked, is plain enough. Mollusca already have the internal structure of vertebrata — the same digestive system — similar nerves— and identical circulatory machinery. The highest mollusks have as much brain as the lowest fishes, and decidedly more than the famous amphioxus—a creature which just now is an obstruction instead of a help in the establishment of a sound biological theory of development; and this for the reason that it is leading us away from the true relations of these orders, and helping to keep up the old misconception of the nature, origin, and importance of a jointed spinal column. Unfortunately, it is this want of vertebræ, of backbone in mollusks, that prevents us from seeing the near alliance of cephalopods to vertebrates. Had the latter been supplied with the more appropriate and distinctive title *Cerebrata*, these highest mollusks might better have claimed admission to the class than many species now found in its ranks. For, besides the homologues already mentioned, do but notice the optic and auditory apparatus of sepia, for instance. These are perfectly identical with the eyes and ears of vertebrates. Notice, again, the organization of the mouth. Only vertebrates have such. In annulosa the jaws have lateral motion, and are modifications of the feet. One other consideration must be mentioned—the size of these animals. Only vertebrata and mollusca seem to have unlimited powers of increase. They only have been distinguished for the magnitude of individuals. Among the latter especially are to be noted the cephalopods for furnishing giants. Did space permit, a thousand homologues might be pointed out.

From all of which results the general conclusion, worked out more fully in my paper on the "Homologues of Organic Creatures," that here is the true route of organic development; the vertebrates from the mollusks, and these from the articulates proceed; and that the basis of the history we are seeking must be searched for in the history of *segmentation*.

All are familiar with the construction of an annulose ring or segment. To the rest of the compound creature each segment is a microcosm, precisly repeating similar parts, or their homologues. To each segment belongs a neural ganglion, or rather a pair of ganglia; a dorsal vessel swelling in the middle to a pulsating organ, or heart, or rudiments thereof; and each is furnished with stigmata, spiracles, or appendages, which are homologous of each other, or, as before, with rudiments thereof. And all these by sufficient analysis are to be traced as actually present in every true segment, however often the function of the homologous structure may be changed, or however it may be reduced to a rudiment, or atrophied, or absorbed and apparently lost. These homologues constitute the basis of biology, as they do of the life-functions of all creatures made of segments, which includes, as we have seen, mollusks and vertebrates, as well as annulosa—possibly, also, molluscoidea; unless the latter should be considered a modified cœlenterate, and then it would be the beginning and unit of the series. If, as sometimes contended (and these are unsettled questions), the molluscoid is an evolution of the annulose type, and its embryonic history tends to prove this, then all the segments have been lost but one. For the molluscoids are monosegmental. Nor is this proposition strange or improbable. Undoubtedly such a reduction to one segment takes place in high orders of genuine mollusks, as in gasteropods (of which you have instances in common snails), in whom one segment has become atrophied, leaving generally a rudiment behind.

In vertebrata, which more immediately concern us, two segments, and only two, are always present, and always bear with them their distinctive elements or appendages, however rudimentary some of the latter may sometimes appear. These segments really constitute the well-known bilateral arrangement of parts and organs so general in animals of this class. Here, again, it is necessary to go back a little in order that we may make the greater speed forward. It is necessary distinctly to understand what we are talking about, and what we mean by segments. In the discussion of the bisegmental organization of vertebrates, the question comes up whether any true homologues exist in the two great classes, vertebrata and annulosa. In the present advanced condition of biology, this question receives a decided affirmative. Until recently the contrary was generally supposed.

When it is seen that two sides of a vertebrate, if it be split asunder down the backbone, present exact counterparts of each other, and also of two segments of any annulose animal—a crustacean or a centipede, for instance; and when we have seen in the progress from unicellular and from monosegmental structures, to the multi-segmental; and from these again to the bisegmental, by lopping off surplus machinery, and by modifying and enlarging what is left in order to increase and intensify the forces evolved; when we actually see these changes, with the attendant change of axis, taking place and becoming the normal conditions of some creatures—all mystery vanishes.

First, let us notice that the so-called vertebrate segments or sections—the vertebræ of the spinal column, are not segments in the sense used here—are not *segmenta*, the biological bracelets, in any true sense; although their development takes place after the change of axis by a growth analogous to the original evolution of annulose segments. The vertebræ are not homologues of the segments of the great segmentarian series.

Having thus indicated what the segments are not, let us call to mind again what they are. This will be the best way to establish the chain we are seeking to comprehend, as it will also be the readiest plan of exhibiting the homologues of these classes, upon which depends all our knowledge of transcendental biology. It is best done, in the few moments left us, by tracing a few of these homologues. For this purpose let us select prominent and obvious organs, for instance, the heart, the brain, and the extremities or appendages.

The first to be noted, being most obvious to popular inquiry, are the extremities or limbs—the true articulæ. Fins, wings, legs, and arms—can these truly be homologues of the arthritic appendages of annulosa? They are indeed. Not half so plain, when first announced, was that first wonderful revelation of comparative anatomy, which displayed the fin of a fish, the paddle of a whale, the wing of a bird, the leg of a horse, and the arm of a man, to be composed of the same organic elements, as is this which now proclaims that these so varied and beauteous limbs of vertebrate animals made the first essays of their evolution as the lateral appendages of aëration or locomotion of the segments of the lowest orders of *annulosa.*

The proofs of this are now obvious, but to appreciate them we have need to travel back again through all the grades of life, and weigh the homologues of every organic element.

Yet some of the evidences are plain, and almost superficial, in the vertebrate class itself. Every anatomist, in order to comprehend the physiology and anatomy of this class, begins his analysis of the vertebrate skeleton by observing two distinct systems of organization—the *dermal* and the *neurohæmal*, heretofore supposed to be peculiar to vertebrates. Now, to which system, the dermal or the neurohæmal, do the extremities belong? No amount of ingenuity can satisfy the thoughtful student that the limbs are evolutions of the appendages of the neurohæmal axis. They are dermal. Even in *mammalia* they have no proper union, no true articulation with the spinal column. Even in those cases where the bones of the pelvis and of the sternum are most securely fastened to the neural axis, it is by a mere anchylosis completed only in the adult age.

The dermal system is the counterpart and homologue of that wondrous external skeleton of articulata, as you must see if you have followed me through the metamorphoses of cœlenterata, entomostraca, and cirrhipeda to mollusca, and from mollusca to vertebrata. Comparative anatomy will not hesitate now to point out every correspondence of every part, every organ, every articulation. Not a bone, nor a scale, nor a hair, is ever lost. In each limb there are so many joints and no more; and with a certain definite relation to each other, clear and true; to be seen in the contorted limbs of articulata, as well as in the arm of man.

Our very limited amount of time compels me to make this address a mere introduction to the subject; compels us to be content with mere *suggestions* for *studies* in biology, to be pursued by after-investigations.

One of these suggestions is made to us by the manner of the *folding* of vertebrate limbs. The difficulties of the question, as put by Dr. Wyman, for example, are well worth consideration, and by this transcendental history of evolution find solution. How is it that in all vertebrates the forward limbs fold one way, forward, and the hinder limbs the reverse? But take you any two segments of an articulate creature, a crab or a grasshopper, and observe how the appendages extend away from the body, and the mystery is explained. For the effect of the magnetic and other forces causing polarity or arrangement is to be searched for and found first in the segments, always remembering that in articulates the axis of the neural system—the life of each segment—is transverse to the general axis of the compound organism. Now, separate two such segments of your articulate—fold them together in the manner indicated by the history of *cypris* and of *lepas*—revolve the involuted creature ninety degrees, stretch the limbs forward and backward as their organization fits them to move; and you cannot fail to perceive a perfect counterpart of the motions of vertebrate extremities.

But this is not half the demonstration. Indeed, it is now so well settled, that Science can, dare make one of those *predictions* always regarded as affording by their verification the highest order of certainty. After noticing the remarkable fact that all vertebrates having limbs have four, or the rudiments of them, and no more, Science predicts with the repose of conscious systematic truth, derived from this doctrine of segmental genesis, that no vertebrate animal, nor the remains of any, ever will be found, on the earth, or in the waters under the earth, or in its caverns or quarries, having more than these *four* homologous appendages—and these always dermal.

But, it may be objected, this is only of external matters, the limbs, the appendages; and these may be accidental correspondences.

Very well! Select any other set of organs. Are there any more internal and peculiar to vertebrates than the brain and nerves? Let us take the neurohæmal system itself, that which confessedly has no perfect counterpart in the articulate class. It is not suggested that any creature lower than cephalopod mollusks presents any thing exactly corresponding to the cerebral hemispheres, and the optic and auditory lobes of the vertebrate brain. But let us see if we cannot trace some homologues? Without this historical derivation from annulose segments there will remain many things in cerebral anatomy entirely inexplicable. To pursue this theme no further at present, the approximation of the vertebrate and the molluscan systems of nerves cannot be doubted. In higher cephalopods, as sepia, the principal ganglia are brought into near proximity—at least resembling a brain. They are even covered by a bony framework, rudimentary of a neural skeleton—in all of which the great cephalopod is decidedly more cerebrate than some fishes, to say nothing of the doubtful amphioxus. But if all else were wanting, the auditory lobes and the optical apparatus would establish this correspondence with the highest orders. The cuttle-fish has an eye with a retina, lens, iris, and cornea; and the optical ganglia are as truly lobes of the brain as they are in mammalia. Nothing like this is seen in acephalous mollusks, nor in articulata. Where articulata have a machinery for vision, it is not organized upon this plan. But we do see centres of nerve-force, or ganglia, appertaining to every segment; and we do see also that the nervous system of sepia is only an advance upon that of the inferior mollusca. Even in the oyster the ganglia are brought nearly to a common centre; and this arrangement does not differ essentially from that in the perfectly equilateral mollusks, as in arca, for instance, except in the nearer contiguity of the ganglia. Finally, comparing arca with lepas and cypris, it is manifest that we have essentially the same plan as in the nervous system of any two segments of articulata. For you will find in each segment two ganglia, one on each side of the median line; and these being brought together, as they generally are in annulosa, appear as one. Now, this one twofold ganglion is, if our explanation of the metamorphoses of the segments be correct, the homologue of the ganglia of muscular motion, of the two principal valves of cypridæ, of cirrhipeds, and of bivalve mollusca; and finds its final evolution in the quadruple structure of a mammalian brain. In fact, the homology is complete, with the additions, or rather modifications, already explained, which endow vertebrates with olfactory, auditory, and optic lobes and systems apparently peculiar.

There is another branch of the internal structure of vertebrates inexplicable upon any other hypothesis than this chain of specific descent. I mean the hæmal system—the system appropriated to the circulation of the blood. Comparative physiology, guided by the light of this metamorphosis of the segments, can have no difficulty in tracing the history of the heart back from mammals, and reptiles, and typical mollusks, to crustacea; and finding it at last reduced to its elementary form in the twofold pulsatile vesicle of the dorsal artery of each double segment of, for instance, iulidæ—lowest of the annulose series. The folding together and stricter union of these segments, as we have seen, bringing these pulsatile vesicles into juxtaposition, perfectly account for the two double hearts of bivalve mollusca, and of fishes; while the approximation and union on the median line of this double machinery of the mollusk explain the fourfold heart and the circulation of the highest types of life.

If you have followed the chain of evolution here briefly sketched, although in mere suggestions, you can have no difficulty in perceiving the unbroken succession of allied links, all the way from the lowest cell-formations up to man. Many forms, doubtless, belong to subordinate systems, and take no part, directly, in the chain; yet the study of all will enable us more fully to comprehend the whole process. In fact, we have no right to expect to find, unless perhaps in fossil forms, the precise *species*—the very *links* of the chain—by which the transmission of *form* and *life* has been actually effected. It would be unreasonable to require this of the advocates of evolution, since the exact contrary would follow, as an *a priori* conclusion, from the very terms of the proposition. It would be a wonder, indeed, in view of all the transitions and transmutations of matter, of force, of time, of place, of forms, if we could find, now living, a single species actually concerned in the long process of evolution—a single "bark which brought us hither." It is just as unreasonable as to demand of us to produce, alive, every individual through whom our descent has been accomplished—just as unreasonable as to demand the resurrection of all the members of our race, for the last thousand years, to prove ourselves Anglo-Saxons. Time necessarily devoured these when the period of life was finished. So has it done with *species;* for, as the species is continued through individuals, *and always with variation*, the distance of removal from any special form is only a question of time. The cosmos is always

"Ein wechselnd Weben,
Ein glühend Leben,"

and, therefore, it takes but a few generations—a few thousands, or a few millions of years—to leave behind any specific type, as completely as the forgotten bones of our progenitors that lie hid in Batavian bogs. Why, with all the lights of human history, we cannot trace the line of any human family more than a few hundred years! And what is the historic period, upon which all doubts and objections are based, compared to the ages multitudinous that have passed away without recognition in human calendars? Take the simplest tree, a few years old. We see a crowning bud at the apex of its principal axis of growth; and we see long lateral branches, likewise, similarly tipped with leaf, bud, and bloom; and we do not doubt their common origin, because there stands the common connecting trunk. Yet neither of these had any part in the production of the others; nor remains there a single one of the individual buds and tender leaves which, in the years gone by, really did take part in the development, the consummation whereof we now behold.

Nor, in regarding man, whom we fondly believe the crowning glory of creation, should we expect to see the precise yearly growths which have finally lifted him to this elevation. The steps of the evolution may still be traced, but not a single individual of the lineal ancestry remains. When, therefore, we speak of the chain of species—of the line of man's descent—upon *a priori* grounds, we do not expect to find, extant in life, the very links of the chain. The loss of them is another proof of evolution. It is thus, according to the plan proposed, we would expect to find it exemplified. It is a rational conception of creation we are attempting to reach, and no other rational hypothesis has ever been proposed.

We do not find, then, the very species through which the ascent to man has been accomplished, and do not seek to find them; but, if this plan of derivation is well founded, as it is clearly rational, we must conclude that the various races of man, now upon the earth, sprang from some common stock, of the order of primates; which, in turn, must have been derived from a lower simian form; and this, again, must have come of a trunk leading back to aplacental mammals; and these lead on to amphibious reptiles; these to fishes; these to cephalopod mollusks; these to bivalve mollusks; these to cirrhiped crustaceæ; which last, in fœtal life, possess all the characteristics of the general articulate or annulose type; annulosa being derived directly from primordial cœlenterata, whence probably issued, also, annuloids and molluscoids. If molluscoidea be the offspring of cœlenterata, then the part played in evolution by the molluscoid type was not to furnish a stage of transition, but to illustrate the power of a segment. In any case, we end with the cœlenterate type, whether fixed, as in actinia, or *occasional* only, as in rhizopods. This last, being the first animal form, causes us to remember that here branches off another great kingdom, of which the life is always exothentic; and which, therefore, has no direct part in this chain, except that its first forms furnish the common stock whence has arisen all organic life.

This wonderfully intimate relationship of the innumerable forms of living creatures, properly considered, is calculated to elevate our conception of the creation, and of man himself; while, to the glory of the Creator, it is held out to us as another "bow of promise"—another assurance of the certainty of the universal reign of law. Nor must it be forgotten that it does not exclude, but, contrariwise, encourages, moral reflections. While it tells man of his dignity, it tells him also of his debasement—that he is sublime in being possessed of so much of his Maker's image as enables him to contemplate all this glorious mechanism; but that he is also "a brother to the insensible clod, which the rude swain turns with his share, and treads upon." It also enforces the reflection of the old poet:

> ". . . . Except above himself he can
> Erect himself, how mean a thing is man!"

THE ZUNI INDIANS OF NEW MEXICO.

By FRANCIS KLETT.

ANOTHER interesting branch of the aborigines of North America is that of the Zuni, a thriving tribe, inhabiting a remote section of the Western United States. This people belongs to the Pueblos, a semi-civilized remnant of the Aztec Empire. Their home is in an uninviting portion of the desert district of New Mexico, about 200 miles southeast of the Moquis settlements.

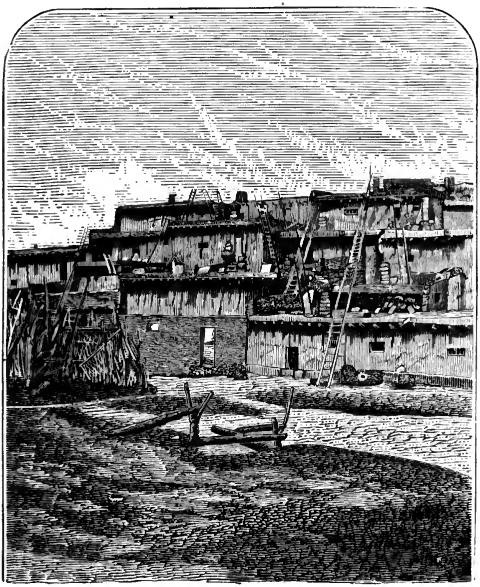
Leaving Fort Wingate, our route lay southwest across a luxuriant, well-timbered spur of the Zuni Mountain, and thence along the Rio Zuni, which was dry, excepting in spots. Passing Ojo de Pescado, a summer retreat of the Zuni, after a weary march through scorching sands, we came, on July 22d, to the suburbs of Zuni town, the outline of whose houses could be traced at a distance of more than a mile; even the characteristic ladder, extending far above the roof, being distinctly visible. As we approached, single dwellings here and there came into view, situated amid corn and water-melon fields. On coming nearer, an old church stood prominently forth, its two well-preserved bells hanging in an opening in the wall over the entrance.

Unlike the Moquis, whose settlements are on lofty rocks, the Zuni town is located on a slight rise above the level of the surrounding plain. Its area is about half a square mile, with streets running here and there at right angles. Much rubbish and *dêbris* are encountered in entering the town. The houses are of *adobe*, terraced, well built, and principally of two—though some are of three, and not a few of even four—stories. As a means of entrance, ladders are used; although in a few cases there are ground-doors (*see* engraving), still the usual method of ingress is by ladder to the second story, thence inside by steps up and down. Some of the dwellings have isinglass windows, while the doors generally are hung on hinges. Each floor is divided into several apartments.

On arriving at the town, our guide, Swzano, a Zuni, insisted on our first visit being made to himself. Climbing to the second story of his house by ladder, we scrambled in after a fashion, and were welcomed by himself and wife, who at once seated us comfortably on sheep-skin rugs spread on the bare earthen floor; bread and water were forthwith handed us, these constituting the simple but recognized symbol of great hospitality among this people.

After a pleasant hour in the company of our guide and his wife, we sallied forth to see the town. Coming to one of the larger houses, we gained ready admission, and were hospitably received. Our presence, however, was the occasion of much comment among the women, of whom we found six in one room. Their peculiar chattering, accompanied by hearty laughter and strange gesticulation, though unintelligible to us, was construed into joking at our expense. The men were in the field at work, while the children were enjoying a bath in the

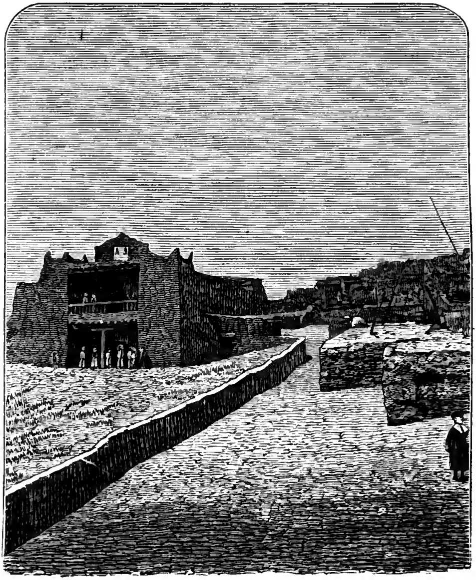
Fig. 1.



Pueblo of Zuni.

muddy waters of the Rio Zuni. The women were engaged in grinding corn and wheat, an operation effected by means of several pairs of large, flat stones, some of coarse and others of fine material. Between the first set of stones the grain is merely mashed, each successive pair rendering the particles smaller and smaller, the last turning out fine flour. Two other women, in another room, were engaged in baking bread, which is made into thin cakes, or wafers, similar to the *marros* of the Jews, only the latter are the harder. On inspecting the house, we found each apartment whitewashed, both walls and ceiling, well ventilated, and in every respect neat and clean; exceeding good order seemed to prevail in the domestic appointments throughout the establishment. The furniture consisted of but few articles, these being principally sheep-skins, Navajo blankets, and water-vessels, the latter used also for cooking-purposes. These vessels are of their own manufacture, of burnt earth, and, in many instances, highly embellished with fanciful designs of neat pattern, the figures being either brown or black, on a ground-work of white. No beds are seen in the house, blankets alone serving as such; the occasional bird-skin, hanging by a string in some corner, serves as a charm. Live eagles and sparrow-hawks, tamed by these people, are seen about almost every house,

Fig. 2.



Catholic Church at Zuni.

great veneration being had for these members of the feathered tribe, which are considered the sacred birds of Montezuma. Each dwelling is provided with a loom, which forms a conspicuous part of the furniture. It consists of two sticks, between which the threads, of the width of the blanket to be made, are spread, the whole arrangement being fastened to the floor and ceiling by raw-hide strings. The operator squats on the ground, using for a shuttle a stick to which the wool for the cross-threads is fastened. The operation of weaving is skillfully performed, although a long time is required in the manufacture of one of their blankets.

The domestic animals of the Zuni are goats, fowl of all kinds, a few head of cattle and donkeys—every family owning several of the latter, which, while serving for transporting wood great distances, as well as for riding, are used chiefly in cultivating the fields. One specimen among the goats had four horns, as shown in the engraving, and was said to belong to the species formerly common among the Navajos, called *cimeron*. The sheep are raised for their wool.

Fig. 3.

Head of Four-horned Sheep.

Outside the town there is a large farm, of which a sketch is presented. It is cultivated in common by the Zuni, although divided into patches, or small gardens, one of which belongs to each family. No rains occurring for long periods, irrigation is resorted to, the water being supplied by the Rio Zuni, in the vicinity of the town; this water is salty. For drinking-purposes, wells are sunk at different points, good water being everywhere abundant at a moderate depth. The staple products are wheat and corn; vegetables are raised in abundance, chiefly onions, *chile* (Spanish pepper), and caraway. From *close* conversation with the people, however, one would suppose their partiality for the first-mentioned vegetable predominated. Melons and pumpkins are also considerably cultivated.

Sauntering about the village, several underground courts were encountered, as well as subterranean passages from one square to another, and to the old Catholic church. This church is of *adobe*, and at least 200 years old; it is 120 feet long, 40 feet wide, and, within, 130 feet in height. The altar is covered with a profusion of carving, which still shows in traces gilding and colors; it has a painted altar-piece of rude construction, representing the ascension of the Virgin Mary; here and there are carved statues of saints, while on the walls are two illegible inscriptions in Latin. In this church, we were told, a zealous priest celebrated the rites of the Romish Church for a brief period; but no *Gloria* or *Te Deum* has been heard within its wall for upward of a hundred years.

The Zuni authorities are a governor and high priest; the latter is called the *cacique*, who, besides being the oracle of the tribe, is their temporal as well as spiritual ruler. No outward personification of their Divine Being is made use of; but, entering their *estufas* (temples) with a *bueno corazon* (good heart), they simply pray for some blessing, looking to no visible object as a medium of intercession between themselves and their God. Although for a time they outwardly observed the religious teachings of their conquerors, inwardly they maintained the belief of their race in the infallibility of their traditions, and soon repudiated the creed pressed upon them, returning to the worship of the source of light—the sun—as their only true God. But not only here were the Jesuits expelled; they were also driven out from the pueblos of Jemez, Acoma, and Saguna, as the ruins of the churches testify. However, at a few points the Jesuits still hold sway, as, for instance, with the Isletta Pueblos on the Rio Grande, while with the Mexicans of New Mexico the Jesuits are everywhere in full power. In times of great drought, and during festivals, the cacique orders the celebration of the *cachina*, a sacred dance. Fortunately, it being a holiday with them at the time of our visit, the rare opportunity was afforded us of witnessing this unique, interesting, and most beautiful though heathenish custom, of which a sketch was made on the spot. Some twenty-seven persons were engaged in the ceremony. When first seen, the participants were standing in a row, their faces toward the sun; they were gayly dressed, as will be evident from the description of the three styles of costume worn on the occasion, and represented in the engraving.

No. I. represents a dancer—costume, light-blue mask, horse-hair beard, necklace of black wool and beads, wreath of hemlock as a waistband; short white skirt, with fancy border, held at the waist by a green and black sash, to which was attached a bunch of long, white strings, hanging to the ground along the left leg; a land-turtle's shell, pendent from the left garter below the knee, contained pebbles which served a purpose similar to the castanet of the Spanish dancer; hemlock around the ankles, yellow eagle-feathers in the hair, and a fox-skin suspended from the waistband, complete the make-up.

No. II. represents the captain, who was attired thus: Yellow eagle-plumes in the hair; blue tunic, white under-garment, with fancy side-piece inserted, and blue stockings; in one hand a staff was carried, the other holding a vessel containing flour.

No. III. represents a female dancer (character taken by male); costume, a white *serape*, with black border interwoven with fancy colors, and a blue gown; otherwise, the attire was that of No. I.

The male dancers stand in a row, the female (males assuming the character) facing them and chanting a low, solemn strain, keeping time with the right foot. In the intervals between the songs, the leader scatters flour to the four winds to appease the anger of their Divine Being, and induce him to send water from heaven. December is the period of their greatest festivity and rejoicing. During this month their God sends his two sons, one to visit the living, the other the dead, of this "his chosen people." Their *estufas* are also used as halls for public meetings.

Fig. 4.

Cachina Dancers.

The executive authority of the Zuni is vested in an officer styled governor—one Pedro Pino—who, however, is but the mouth-piece of the spiritual ruler, the cacique; the orders of the latter are the laws governing the tribe, their execution simply resting with the governor. In conversation, Pedro Pino informed us that he was the ruler of the country between the Neutrias and Colorado Chiquito, some sixty miles, and Agua Fria and the Moquis settlements, about one hundred miles apart. In appearance, he is perhaps sixty years old, of commanding presence and affable manners; his hair is snow-white. He told us he had been governor of the Zuni people for many years, and that the tribe had always been friendly to the whites (Americans), from many of whom he had testimonials to the latter effect. Ordering his son, Patrizio, to bring him certain papers, he produced letters from officers of our army and private citizens, which referred to the governor in the highest terms, and also spoke of the uniform kindness in their treatment of his people.

"The Americans," continued the governor, "treat us well, but the Mexicans very badly; the latter have always maltreated us, and we want them neither to go through our country nor to reside among us. The heavens punish us by long drought for allowing them to remain on the Colorado Chiquito. My cacique, who prays for rain, and who is the spiritual and temporal ruler of this people, watches the sun daily, and is much distressed because no rain falls. He (the cacique) attributes the drought to the presence of the Mexican on our soil."

Pedro Pino bade us tell the Great Father that he wanted a "perpetual title to the Zuni country, which," he said, "had been handed down to us by our forefathers, through all time." Further, he remarked: "We are peaceable, and do not make war; if we have a title to our lands from the Great Father, we can show the document, and even the Mexican will respect it." The cacique, who was present, nodded assent, but did not join in the conversation.

The governor very cheerfully and politely accompanied us through the village. As the *cachina* dancers came in sight, and we halted to witness the ceremony, an elderly man approached and remonstrated with the governor for allowing us to look upon this form of worship. In reply to the remonstrance, Pedro Pino informed the intruder that he would allow us, "but," said he, "no Mexican shall ever look upon the performance of this holy and sacred rite. The Americans," he continued, "have ever been our friends, and are good and excellent people. I have been in Washington, and have seen such men as Monroe and Calhoun, and have been in the halls of Congress. These men" (pointing to us) "come from Washington, and I know they are good men." To the last remark *we* bowed assent.

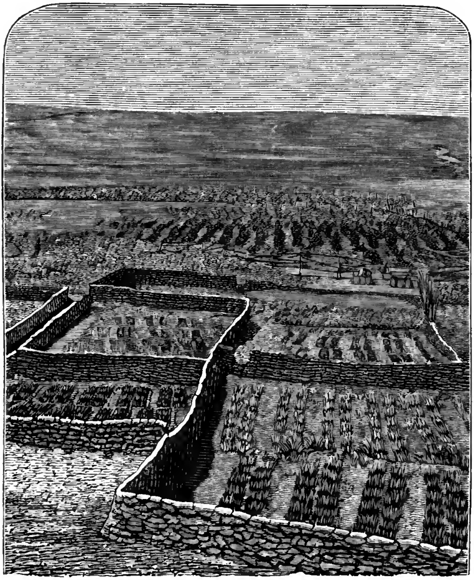
On returning with the governor, we were most cordially welcomed to his house, and, entering, were very agreeably and hospitably entertained. A pipe "all round," and Pedro Pino entered into conversation. He spoke of a single Mexican at Ojo de Benado, and another at the Colorado Chiquito, who were a sore grievance to his people. He said: "The cacique of my nation is very sorry on this account, and the rain will not fall while these wicked men inhabit our territory. I will deem it a special favor if you will intercede with the Great Father for a title for us to our country: this will satisfy us. You men are good, have seen the sacred dance of the *cachina*, and we shall have rain." It may be a fact of importance to the superstitious to know that it *did* rain that evening, and most heavily, the storm lasting several hours!

The traditions of the Zuni are few and simple. They say their people came from the northwest on their march southward; that all Pueblo Indians belong to a common race, and are all members of the large families called Aztecs, or Montezumas; that some of their forefathers remained behind in the great migration of the nation, while the large body pursued a southerly course, ultimately forming the mighty empire of Mexico, as found by Cortez after its conquest; that, long before the white man came, their people inhabited the *mesa* south of their town. They have traditions, also, of a flood; of the founding of their present *pueblo;*[1] of their war with the Spaniards, and their subjugation, by the latter, for a time; of the arrival of the first American in New Mexico, and of the Mexican and Navajo War. But their knowledge of these events is merely outline, they being unable to give any details.

[1] Used for "town" as well as "people."

The Zuni language is much like that of other Pueblo Indians, but the words are, apparently, rather indefinite, requiring much facial contortion and bodily gesticulation to make their sentences perfectly intelligible. They have no schools. Their hieroglyphical writings may be seen in many places, while all along the Cañons de Choca and de Chelle are traces of the ancient march of this people. At Mesa Pintada (Painted Rock), about 100 miles to the northward, we copied one of their hieroglyphical inscriptions, as seen in the engraving. This writing being in the Navajo region, is believed by some to be the

Fig. 5.

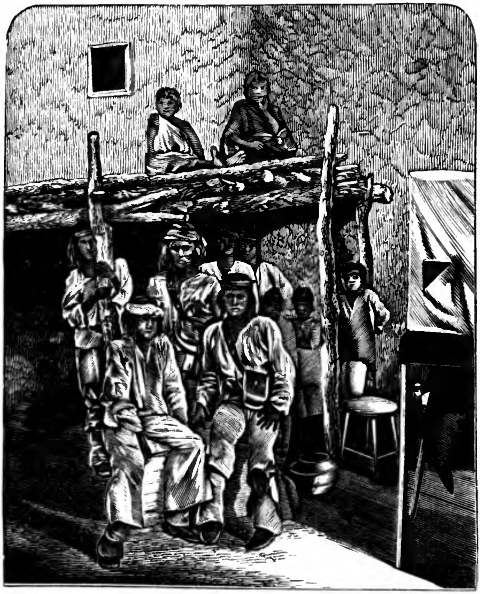


Zuni Vegetable-gardens.

work of that tribe; but this could hardly be, since the Navajoes are a nomadic people, and, besides, are not known to possess hieroglyphical writings. The Mesa Pintada is a vertical wall of sandstone, about 150 feet high. The inscription, as here given, was copied on the spot, and is a faithful representation. Commencing at *a*, the writing runs, with the mesa, westward; the space from *a* to *e* is 16 feet; the figures are reduced to one-fifth their original size.

There are many ruins of stone-houses in the vicinity of Zuni, at Agua Fria, El Moro, Ojo de Benado, and Old Zuni, which were undoubtedly towns inhabited at the time of the Spanish conquest, constituting, with Zuni, Neutrias, and Ojo de Pescado, the *Seven Cities of Cibola*, mentioned frequently by Castañede in the description of his travels in 1540. The opinion of the chief officer of this expedition, Lieutenant Wheeler, is in accordance with the views of General Simpson, Lieutenant Whipple, Mr. Gallatin, and other ethnologists. Moreover, the governor of the Zuni informed us that all the ruins in question were once thriving towns of his people. In connection herewith it may be mentioned, that near Zuni is a rock with an old Spanish inscription, which our party photographed.

Fig. 6



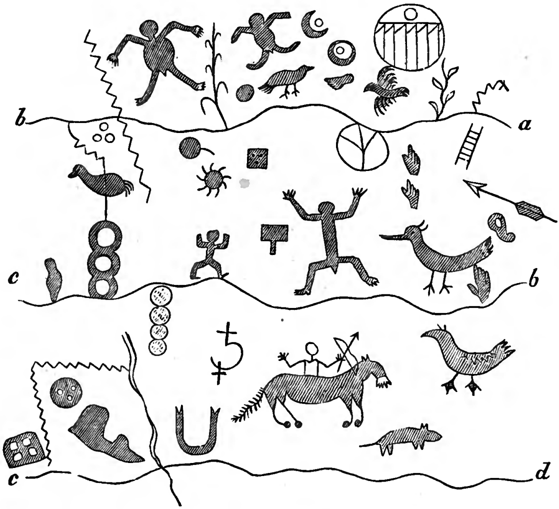
Group of Zunis.

The Zuni number about 2,000 souls. In summer, parts of the tribe resort to the smaller settlements—one at Neutrias, the other at Ojo de Pescado (respectively about twenty miles from Zuni town)—to cultivate their farms in those sections. Their fields do not compare unfavorably with those of the Mexicans.

In appearance, the Zuni are a mixture of Mongolian and Caucasian. The complexion is olive, rather than dark-brown; hair straight and jet black; eyes black; cheek-bones very high and prominent; their height and general *physique* correspond to the average among the whites. Their dress is simple, that of the men being merely cotton drawers and shirt, with blue woolen stockings of their own manufacture; a turban of wool or cotton completes the male attire. The females wear a gown of wool, held at the waist by a sash of the same material; the arms and shoulders are left bare; their stockings same as those worn by the men; for shoes, both males and females wear moccasins of buckskin. When in the street, the women cover the head and shoulders with a white cloth.

Among the Zuni, as well as other Pueblo Indians, are many albinos, and, as interesting to those inclined to the Darwinian theory, it may be stated that the production of this "improved stock" is not due to any mixture of white blood. The skin, and sometimes the hair, of these singular specimens of humanity, is perfectly white, while their eyes are of a reddish hue. The mother of an albino being asked why, she being *brown*, her child was *white*, made no reply; her fierce look, however, expressed more, perhaps, than her language would have revealed.

Fig. 7.



Hieroglyphics at Mesa Pintada.

Several tribes of Pueblo Indians have been contaminated by contact with the Spaniards, but the Zuni are still pure, and free from taint through Spanish influence. They are simple, though ceremonious in manners—the latter trait undoubtedly acquired from occasional association with their Latin conquerors. They are extremely hospitable, and, after short acquaintance, are apt to prepossess the stranger and to command his respect. The females are chaste, reserved, extremely modest and rather shy, avoiding, when possible, the gaze of the stranger. Many of them are quite pretty, of fine figure and regular features. Their want of personal cleanliness, however, was apparent, and is certainly singular, in view of the neatness which pervades their dwellings.

One cannot but admire their regard for truth, their industry, unobtrusive disposition, hospitality and respect for strangers. Their hatred of the Mexican is intensely bitter, and is not concealed. On every favorable occasion they give vent to expressions indicative of outraged feelings by reason of the persecutions that have been inflicted upon them by their enemies; and these, together with the feeling manner in which they are made known, warrant the belief that the injuries they have suffered have been numerous and severe. Their love for and kindness toward the people of the States (or "Americans," as they call them) are in striking contrast with the hatred and revenge they bear the Mexican. Yet the benefits they have received from our Government have been neither many nor great.

Although perhaps these Indians, like all Pueblos, do not impress the stranger very favorably on first sight, on closer acquaintance one is forced to yield to the conviction that they are among Nature's noblemen—that they are the descendants of a race long freeholders of the soil of the North American Continent, and are every way worthy of confidence and respect. They are by no means to be compared to the nomadic tribes of red-skins, everywhere infesting the prairie, plain, and mountain of the far West, for murder and plunder. Like other Pueblo tribes, these people show marked and distinctive peculiarities, not that they differ essentially in type from the other branches of the great aboriginal families, but as regards their originality in costume, and their strong conservatism. Industrious and self-sustaining, they are temperate and quiet; though receiving but little aid from the General Government, they are well to do, and particularly in the line of farming.

As evening drew near, we prepared to bid adieu to Zuni town and its inhabitants. On leaving, the governor, with his cacique and the prominent men of his tribe, followed us to the outskirts of the village, when, with uplifted hands, he gave us his benediction, imploring the God of the Zuni to give us safe return to our camp, and, at the close of the field season, to our homes and kindred in the distant East.

A pleasant day with this isolated band of self-supporting, half-civilized people, was profitably spent, many facts being gained regarding themselves, their ancestors, their peculiar manners and customs, as well as respecting their language. These data, when properly discussed and elaborated, will constitute additional information of interest to the general reader, as well as of value to the student of ethnology and philology, and may, moreover, throw new light on the history of the North American aborigines, of whom but a handful remain to tell the story of their former greatness, or the extent of their ancient civilization.

FOOD, AND THE DEVELOPMENT OF MAN.

By OTTO ULE.

TRANSLATED FROM THE GERMAN, BY J. FITZGERALD, A. M.

THE progress of science does not consist merely in the discovery of new facts and the enlargement of our knowledge, or even in the ingenious conclusions thence drawn, and which, from their universality, acquire the character of laws; its mightiest work is the change it brings about in our fundamental conceptions, and the consequent revolution in science itself. As science advances, it gains new principles, new arguments; its problems and its aims multiply incessantly. There is no branch of knowledge that has not experienced this, and even historical investigation is no exception. Time was when the earth used to be regarded as merely the temporary abode of man, or even as the place where he spent a brief term of banishment. The history of man used to consist of casual events, or of the free and arbitrary doings of individuals. Great men, great heroes, great rulers, great thinkers, determined the history of peoples and of states. Trifling causes—the walling up of a window, or the spilling of a glass of water—might occasion events that would convulse the world. By the aid of natural science we have come to look on the earth as something more than the temporary abode, as the true home and school of mankind. Man has become a child of Nature; in Nature are all the conditions of his life and development. Climate and soil, the conformation of the land, and the distribution of water, determine the physical and the mental development of nations. It has long been seen that peoples differ, that their history and their civilization are different, accordingly as they live in valleys or on mountains, in islands or in the interior of continents, in deserts and steppes or in forests, in an open, hilly country, or in sequestered valleys. Historical research, however, has but recently begun to concern itself with the natural causes of the development of civilization, and many an important aspect of this subject is still entirely overlooked.

Of all the influences which determine the life of the individual, and on which his weal and woe depend, undoubtedly the nature of his food is one of the weightiest. Every one has for himself experienced how not only the strength of his muscles, but also the course of his thought and his whole mental tone, is affected by the nature of his food. And shall not that hold good for nations which holds good for individuals? Shall the sum of mankind be less affected in their physical and mental development by the food they take, than the individuals of whom that sum is made up? This seems to be the decision of history. Philosophers (even the great thinker of Königsberg himself) have not a word to say about the influence on human races and peoples of different food-supplies. The world heard at first with astonishment the saying of a famous scientific man, that, "could man live on air and water alone, such notions as master and servant, prince and subject, friend and foe, hate and love, virtue and vice, right and wrong, etc., would have no existence, and political communities, social and family life, human intercourse, commerce, trade, and industry, art and science—in a word, whatever makes man what he is—depend entirely on the fact that man possesses a stomach and is subject to a law of Nature which compels him daily to take a certain amount of food."

As we start out with the principle, too late recognized in historical research, that the selection of articles of food is not only important for the personal well-being of the individual, but that it is a weighty, world-stirring question for countries and nations in its bearings on the history of civilization, we will, therefore, endeavor to look closely into it, and study the mode in which this influence is exerted.

If nations are to flourish, they, no less than individuals, need wholesome, strong food. The only question is, How are we to determine what food is strong and wholesome? Foods have been classed in different groups, according to the influence they have on the body, in virtue of their essential constituents; and though this classification, like every artificial classification we make in Nature, is only approximately correct, still it gives us some ground to stand on. Blood-formers, or albuminates, are those albuminous materials which constitute the nutritive elements of the blood, and enter into the composition of the muscles, bones, sinews, and ligaments, on which the exercise of force specially depends. The heat-producers or respiratory foods are those rich in carbon; these specially serve to support, with the aid of inspired oxygen, the process of combustion so necessary for the purposes of the organism. Finally, there is a third group of nutritious substances—the nutritive salts—which are of an inorganic nature, and which, after combustion of the food, remain in the shape of ash.

All these food-materials are essential, since with them the organism is built up. Life is an unceasing process of waste and repair, and the food must make good the loss the organism suffers every instant. Even those substances which are contained in the living body only in small quantities must be supplied, for on this depends the activity of important organs. Such substances are common salt, potash, lime, magnesia, phosphoric acid, and, above all, iron, without which the blood-corpuscles would lose their vitality. But none of these groups is, by itself, sufficient for nutrition; they must all be combined. Blood-formers, heat-producers, and nutritive salts, are not separately foods, but only factors of food, each as indispensable for the vital processes as air and water, but each incapable by itself of supporting life. One cannot live on albumen alone or on fat alone. Without lime-phosphate no bone would be formed, no matter how much pure albumen and fat we ate; and without albumen no muscular tissue would be formed, though we were to gorge ourselves with sugar and salt; finally, without fat, no brain. But we properly enough give the name of foods to meat, milk, and bread, for in them all the three conditions are present.

Fortunately, these nutritive principles are found by no means sparingly distributed throughout Nature; under the most varied forms they occur in almost every food-stuff used by man. We not only find the blood-formers in the shape of fibrine in the blood and muscles of animals, of albumen in eggs, of casein in milk, of lime and areolar tissue in cartilage, sinew, and skin, but also in the vegetable kingdom; we discover them in the gluten of grains, in the legumine of pulse, in the vegetable albumen of sundry roots, leaves, and fruits. Heat-producers are furnished, not only by the animal kingdom in its fats, but by plants also. Sundry seeds give a small quantity of oil, but the principal supply of heat-producing elements derived from the vegetable world appears in the shape of starch, gum, and sugar—substances which, during the process of digestion, are transformed into fats, and therefore may replace the latter. Finally, we have salts in the water we drink, and more abundantly in nearly every animal and vegetable substance we consume. Hence, it might seem to be an easy thing to find wholesome food, as though one had only to seize blindly the store of food offered by Nature, in order to get all that our organism requires to keep it vigorous. But it is not to be forgotten that, while the nutritive elements make up the losses of the organism, and renew the body, as it were, still they must be taken in certain definite proportions. Now, in Nature they are not distributed in any such proportion. There the greatest diversity is found; one food-stuff consists principally of blood-formers, another of heat-producers; this one contains only one of the nutritive salts, that one, another. If, then, we let chance decide in this matter, it might easily happen that we would take one element in excess, while we took none at all of another. If this were the case again and again, or permanently, the organism must suffer or perish utterly; for, suppose only a single organ to be improperly nourished, i. e., to receive food insufficient to make up its losses, the check given to this one will affect all the rest. Science can now pretty accurately determine the composition of every article of food, and hence its contents of the various nutritive principles. This is done by chemical analysis. Chemical analysis, however, is of little assistance to us in determining accurately the constituents of our daily food. For, if one, being over-anxious on this point, wished to avoid all danger by having all his food examined by a chemist, so as to apportion by weight the amount of this substance and of that which he should take, there is reason to fear that he would die of hunger long before the chemist had concluded the analysis. Fortunately, there is a better method of avoiding danger, and of this we wisely make use under other circumstances. When we would protect ourselves against the chance which gives up our houses to destruction by fire, or when we would secure our dependents against the accident which deprives us of life and them of a protector, we take out an insurance policy on house or life. But this insurance is not a transaction between two or three, but between hundreds of thousands and millions. A mutual insurance transacted between three persons were a game of chance, between millions it is a sure calculation. We defeat chance, when we share it with others. To apply all this to the matter in hand: we must not restrict ourselves to a few articles of food, but must have a great variety of foods to select from; we must not partake of the same fare day after day, but must vary it as much as possible. Only with a varied and alternating dietary can we be sure that what is lacking in one food-stuff will be supplied in another, and that what we fail to get to-day we shall have to-morrow. What is commonly regarded as simply the result of a spoilt palate, viz., the repugnance excited by the steady recurrence of the same dish, is an uprising of the organism itself against a food which does not meet its requirements; or, rather, the consequence of a deficiency already established.

Here we have an important rule for determining a wholesome diet. The foods we use must contain the indispensable elements of nutrition in due proportion; our food must be mixed, varied, and alternating. And what is here said with regard to individuals, holds good also for nations. The food-stuffs of an energetic population are up to the standard only when they are multifariously blended, and when there is a due proportion of substances belonging to the three groups mentioned above. Now, this relation between the nutrition and the physical and mental development of a people must be apparent in the history of their civilization. Where the food is insufficient, fluctuating between want and excess, uniform and undiversified, the capacity of the people for work must be inferior; their bodily strength and their mental culture must be of a low grade.

But, when we turn our eyes to the pages of history for a confirmation of this, we meet with our first real difficulty. History tells us much about deeds of heroism, bloody wars, conquests, and revolutions; of politics, manners, and customs, and even of the thoughts that have occupied the minds of nations; but of their *cuisine*, their bill-of-fare, history tells us nothing. And yet a history of the foods of nations would be an addition of great value to the history of human civilization. From it we should learn by what means and in what way the men of prehistoric times came into possession of their food-stuffs; and this would be a long story full of deeds and full of suffering. Fortunately, we possess other original documents besides the annals of history; documents, too, that antedate all written history, and which are no less trustworthy and unambiguous. The ground under our feet has preserved them in its strata; they rest in barrows and in caves, and in the bottom of lakes and bogs, and these primitive documents are not silent as to the food of extinct nations.

In the present status of research, the earliest authentic traces of man on earth go no further back than the age of ice, so called, and the accompanying or subsequent formation of the diluvium or drift. The relics of man dating from an earlier epoch, the upper Miocene formation, that is, the middle of the Tertiary group, which are said to have been found in France, are at least very questionable. But there have been preserved for us in caverns remains dating from the Ice Age, which tell us of the food used by man in those times. Man then inhabited Central Europe in company with the reindeer, the cave-bear, and the mammoth. He was exclusively a hunter and fisher, as is shown by the bones of animals found in his cave-dwellings. The miocene vegetation, which abounded in arboreal fruits, had disappeared during the long period of the subsequent pliocene formations, the climate of Central Europe, meanwhile, having gradually become colder. Nature supplied no fruits for the food of man. What food he got by hunting and fishing was precarious, and there were intervals of famine; for fortune does not always smile on the hunter, and the beasts of the forest are not always equally numerous. The food, too, was uniform, and not altogether adapted for man, for the flesh of wild animals lacks fat. The man of those times had not enough of the heat-producers in his food; and that he felt this want, we learn from his taste for the marrow of bones. All the long bones of animals that are found in cave-dwellings are cracked open lengthwise, in order to get out the marrow. Now, this insufficient, uniform food has its counterpart, in the low grade of culture which then prevailed, as evidenced by the mode of life, the weapons, and the tools. Man then lived isolated, without social organization; he dwelt in caverns, and his only protection against the cold was the skins of animals and the fire on the hearth. His tools were of stone, unpolished, unadorned; so rudely fashioned, that only the eye of the connoisseur can recognize in them man's handiwork.

Let us now advance a step further, and glance at a time a few thousand years nearer to our own, the period of the ancient pile-dwellings. Man then built up huts, and even villages, on piles, in the midst of lakes. These piles have been discovered, and between them, on the bed of the lake, oftentimes overlaid with peat several feet in depth, lie the monuments of those times—the waste of the house and of the kitchen. Some of these lake settlements, that near Robenhausen, in the Pfäffikonsee, for instance, were clearly destroyed by fire, and under their charred remains is buried every thing that had been contained in the eating-rooms. The lake-men, too, were hunters and fishers, and they still hunted some of the same animals as the cave-men—only the cave-bear, reindeer, and musk-ox had disappeared. They pursued fishing probably with greater success than their predecessors, for they not only employed harpoons made of bone and reindeer horn, but had learned to make nets of flax-fibre. But they, furthermore, had begun to raise cattle; they had domesticated animals—goats, sheep, two species of swine, and two of oxen. Probably, too, they used the milk of cows, and even seem to have understood cheese-making, for twirling-sticks and perforated vessels have been found which can hardly have been used for any other process. The food-supply of the lake-men, therefore, was more assured than in the Ice Age, and also more varied; for they were, furthermore, agriculturists. They grew wheat and barley, ground the grain with querns, made porridge and bread. Remains of this porridge, as it is supposed, have been met with in pots; and flat cakes, in a charred condition, are found abundantly in the pile-dwellings of Wangen and Robenhausen. Sundry kinds of fruit, also, served for food. Dried apples and pears—wild-apples and wild-pears, it is true—blackberries, and hazel-nuts, have been taken in great numbers out of the bogs. The food of the pile-villagers was thus very abundant and diversified, and to this better nutrition answers a considerable advance in culture. The lake-man did not inhabit caverns, nor did he clothe himself in skins, as did the man of the Ice Age, but built himself wooden cabins, and wore clothes of flax. Considerable stores of flax have been found, and it is even supposed that pieces of the simple fabric have been discovered. These people lived in populous villages, and hence undoubtedly had a social organization. Their tools and weapons are of stone, it is true, but nicely polished and ornamented. Their unmistakable love of the beautiful testifies to their progress in culture.—*Die Natur.*

MATERIALS OF THE SCIENCE OF LAW.[1]

By SHELDON AMOS, A. M.

IN order to ascertain what are the materials of the Science of Law, it will be well to cast a glance at the subject-matter, in its rudest and most inartificial shape, to which the science relates. For this purpose the case may be taken of a nation in what may be called the

[1] From advance sheets of "The Science of Law," forming Vol. X. of the "International Scientific Series."

early manhood of its life, after all the early struggles for its self-conscious existence, or for its independence, are over; and yet, before it has developed within itself all the complicated machinery of a highly-organized commercial and social life. In such a state there must, by the very hypothesis, be a more or less steadily fixed government, whether that government approach more to a monarchical, or an aristocratical, or a democratical type. The stability of the state, and its self-dependence, imply agriculture, and agriculture implies property or ownership. The division of labor, again, which this economical condition presupposes, involves the habit of making contracts, even though they be of the most elementary form. The social condition cannot but rest upon a previously-developed, though now strongly-fortified, domestic condition, and this implies the fact of marriage, and the relations of husband and wife, parent and child, brother, sister, uncle, aunt, nephew, niece, and the like. The still remaining anarchical tendencies of certain individual members of the state, lagging behind the rest, will generate occasional acts of violence, threatening, directly or indirectly, the very life and existence of the state. These acts will excite the horror of all the more orderly members of the community, and will be denominated by some such term as *crimes.*

It is obvious that the characteristic classes of facts, which have just been alluded to, are so general and simple, that their necessary occurrence at a certain epoch, in the progress of every state, may be predicted as a certainty. These facts, however, in themselves, are of the utmost possible moment, and involve, by their permanence and universality, the elementary ingredients of a science of law.

It will be seen that these facts, looked upon as a whole, imply, first, a certain number of definite relations of persons to one another, whether as governors or governed, husbands or wives, parents or children, or as otherwise allied by blood or marriage. Secondly, these facts involve certain determinate relations between the persons in the community, in respect of the things (or physical substances) appertaining to the community as a whole. These things, severally, are owned by one or another, and not by the rest. The ownership of these things is the subject-matter of private arrangements and contracts between different members of the community. The violent or fraudulent abstraction of a thing owned from the owner may be one of the acts on the general prevention of which the very life of the community is held to depend, and as such is denominated a *crime.*

Again, the classes of facts already enumerated have two distinct sides to them, one touching the outward lives of members of the community, that is, their *acts;* the other touching their inward lives, that is, their thoughts and feelings. Over the former of these sides the whole of the community can, by its aggregate pressure, exert a considerable amount of force, of a specifically ascertained quantity and quality. Over the latter side, that touching the thoughts and feelings of individual members, the utmost direct pressure, consciously exerted by the community, is of the feeblest efficacy, and, at the best, indefinite and precarious in the highest degree. The sphere of action of the community, with respect to the former, or the acts of men, is that of law. The sphere of action with respect to the latter, that is, the thoughts and feelings, though not exclusive of acts, is morality. The relations of these two spheres to each other will be investigated in the next chapter.

In the mean time, the following conclusions have been reached: It appears that the characteristic energy of every state consists in the reciprocal influence upon each other of the corporate whole, and the constituent elements, in respect of certain definitely assignable classes of human action. These classes of action will either have reference to things or physical substances, as objects of ownership or use, or have no such reference. The actually subsisting relationship to each other of the corporate whole, and the constituent personal elements, depends upon the form of government which casually happens to prevail.

The influence of the constituent personal elements of the state upon its governing authority, as representing, at any epoch, the corporate whole, is exhibited, first, in the selection (whether conscious or unconscious) of that governing authority according to its specific modifications; and, secondly, in the incessant control (conscious or unconscious) of that authority, by which the limits of its free action are, at every moment, defined. The influence of the governing authority, on the other hand, on the constituent personal elements of the state—that is, upon its so-called "subjects"—is exerted through two separate channels: one that of administration; the other that of law. In other words, the purposes of government are effected either through the medium of occasional and, as it were, spasmodic injunctions, or through general rules.

The limits, within which any given governing authority can venture to issue occasional injunctions, must be determined, as has already been seen, by its actual relations to all the constituent personal elements of the state. These limits will never be precisely determined in language, though they will be marked with tolerable exactness in fact, and instinctively appreciated by all persons concerned in either enlarging or protecting them.

The determination of these limits of administrative authority might be looked upon as forming one great branch of the general rules which constitute the other field of the appropriate activity of the government. It composes a large portion of what is called "constitutional law." The anomaly, however, attaching to this extension of the term "law" is obvious, inasmuch as, if the name "law" be given to the body of general rules through which a government exerts its appropriate activity, the same term "law" cannot be simultaneously applied to the limits affixed to its freedom of action. But this objection, when once understood, is of little practical importance. It is sufficient to establish that there are certain definite limits which circumscribe the free action of every governing authority, and that these limitations admit of being formulated into more or less precisely articulated propositions. Such propositions, capable as they are of being handled, interpreted, and enforced, in courts of justice, have all the essential qualities that belong to the general rules framed by the governing authority itself, for the guidance of the conduct of all persons submitted to its dominion.

The topics of these general rules or laws will be those matters which have already been described as essentially inviting the direction of the corporate strength of the community. Such matters are the relations of family life, so far as outward actions and public decorum are involved, the security of property, the protection of individual liberty, the enforcement of contracts, and the prevention of those violent and exceptional excesses denominated crimes.

At a very early period in the history of the community, the interest that each citizen has in the wise and effectual regulation of such matters as these becomes conspicuous to all, and more especially to those usually, or, on the average, more advanced and intelligent members of the community who find themselves charged, through, it may be, a series of political vicissitudes, with the duties of government. It is probable that these several and various objects will attach to themselves, at different epochs, a very unequal and disproportionate share of attention.

The security of property may alternate with security of the person as an object of governmental care; and the classification of crimes and civil injuries, or even of crimes and religious offenses or sins, may be, in the highest degree, irregular and unsystematic. The vices, the selfishness, the ignorance of individual rulers, will, from time to time, bring into relief some classes of laws to the disparagement or neglect of others. At one epoch a state will suffer from having too few laws, at another from having too many. Particular classes of persons may lose or gain at one period of legislation, and other classes may lose or gain at another. These eras and disasters are of none the lighter consequence that they have been universal. It is in spite of them, and not by means of them, that states have finally endured and fought their way to a climax of intelligent legislation and conscious political life. In the case of such states, the heart of the people, as estimated from generation to generation, has been sound, and the heads of their rulers wise. The laws have gradually been adapted to promote individual liberty, and not to impair it; and the province of government has been so mapped out as to make the government an institution conducive to the good of the people, and not a mere organ for the sacrifice of a nation to a class.

It will have been seen, in the above description of universal phenomena, that a purely abstract mode of treatment has been adopted. So far as universally confessed historical facts are presupposed, the truth of such facts is boldly assumed. But the main basis of the arguments are the elements of human nature itself, as they are written, not only in the venerable documents of ancient history, but on the face of every traveler's narrative, of every ancient body of laws, of every honored institution subsisting in the midst of the national life of the most advanced countries of Europe. It is obvious, then, that the generality and permanence of the momentous facts above described afford the groundwork of a great science, the Science of Law.

This science is distinguishable from the Science of Ethics, to which it may be coördinated, as well as from the Science of Politics, to which it is subordinated. The materials of the science are: a description of—1. The essential institutions of human society, by the use of which the objects of that society are carried out through the medium of government; 2. The nature, conditions, and limits of *law* as an expression of that side of governmental action which consists in the enumeration of general rules of action; 3. The accidents of law, such as language and interpretation, terminology, and devices for legislation.

When these materials are carefully scrutinized, it will be found that they are composed of elements as permanent and universal as the elements of human nature itself. All that is arbitrary and idiosyncratic for any particular state is banished from the inquiry. The surplus is as applicable to one state as to another; to the most immature system of law as to the most advanced; to an Eastern as to a Western community; to the modern as to the ancient world.

It is curious that this universality and permanence have been generally conceded to ethical truths, and have latterly been more and more freely conceded even to political phenomena, modified indefinitely, as these must needs be, by the excessive complexity of the conditions which constitute them. But the region of law has, up to a recent time, been held to be the natural home of caprice and irregularity. Some writers, indeed, such as Montesquieu and M. Charles Comte, have quoted the varying laws in the different countries of the world with almost an ironical gladness at their *bizarre* and party-colored appearance. It has been very generally held that governments have been created by violence or accident, and have reflected the vices of their origin in the reckless selfishness of their legislation. It has been said again and again that force is the origin of all social institutions, and that the modes of directing that force have been determined in every state by the chance breath of political caprice or passion. It has been forgotten, or has escaped notice, that the caprice has been accidental and the order is essential.

It will be noticed that there are two distinct conceptions of human society which are both possible, if not both true, and that the existence of a Science of Law follows as a necessary consequence of the adoption of one conception, but does not follow from the adoption of the other. It may be said, on one theory, that the composition and action of human society, as exhibited in the state, are due to nothing else than the aggregation and mutual repulsion of a number of independent and self-conscious atoms which, by a gradual process of experience, have discovered that the largest measure of individual well-being is solely attainable through certain special modes of coöperation. These modes of coöperation take a variety of forms, but the most signal and important are those implied in the facts of government, ownership, the composition of the family, and contract.

According to the theory now under review, every one of these facts is merely a device for carrying out ends believed to be beneficial. The facts might be made to vary indefinitely, and it is alleged to be conceivable that any one of them, and perhaps every one, might be absent altogether and a new set of devices take their place. It is held to be possible that the devices themselves will, at no remote period, be discovered to be rude and insufficient, and that many superior substitutes could be found for them, even if they do not already exist in certain societies, the constitution of which is as yet unexplored. The machinery by which each one of these classes of facts is called into being, and made to subserve its end, is physical force, taking the form of what is called law. The physically stronger part of the community compels the weaker to obey a certain form of governing authority, to recognize certain descriptions of ownership, to conform their lives to certain canons of domestic life, and to observe certain regulations of the market and the exchange. The rules, indeed, enforced by law are, for the most part, so transparently beneficial to all concerned that the pressure of law becomes very slightly felt, and the physical force which supports it is comparatively seldom called into play. Nevertheless, in the theory now being enunciated, force is not only present, but the main originator and upholder of every portion of the fabric of social order. It is obvious that, according to this view, there can only be a Science of Law in a very restricted sense. In the largest sense of the expression there can be none. Instead of law having any precise and determined character impressed upon it and upon its operation, through the existence of a certain number of immovable social institutions, which react back as effectually upon law as law acts upon them, these institutions are nothing more than the creations of law itself, or rather the accidental shadows which law happens to cast.

The opposite theory of society starts with the conception that society is not developed through the conflicting passions of individual atoms striving to organize themselves after a fashion which shall best promote their own well-being, but is from first to last a subsisting organization made up of constituent groups reciprocally acting and reacting upon one another. The elemental forms and tokens of this organism are family life, ownership, and government. Each of these presupposes coöperation and contribution at all stages in the history of society, though under different forms; each of them implies the distribution of mankind into small groups rather than into large masses of individual atoms. It is difficult to say that any one of these original elements has precedence in point of time over any one of the others. It is more true to say that, when once they are all found to be in existence, the state has then and there come into being. A very short time passes before another element—that of contract—implied in all progressive industrial coöperation, also comes to the surface.

There are thus formed in the primitive state a certain number of elemental institutions which may be looked upon, not in any sense as the creation of law, but as existing independently of law; for the spontaneous arbitrary action of a primitive government resembles what is now called "administration" rather than law. It is true, however, that law, in the immature form of regulated usage, will be found to be one of the earliest of all the ingredients of the state. It will be, indeed, even from the first, the regulator and the guide of the other institutions with which it is contemporary, but is in no sense their parent or solitary guardian. Nevertheless, as time goes on, the support that law gives to the integrity of family life, to property, to industrial and commercial relations, and to government, becomes important in the highest degree. Indeed, the prominence of the legal supervision exercised in a highly-developed state over all these departments, affords an apology for the familiar notion that they are all the arbitrary creation of law and depend for their continued subsistence upon no greater or deeper sanction than that of physical force.

If it be true, then, as this last theory asserts, that in every state there are a limited number of great pivots, or turning-points, round which human society revolves, and the law only plays a subordinate part in regulating and protecting the grand mechanism, it is obvious that a permanent and universal body of facts relative to law may be at once anticipated to result from the permanence and universality of the great groups of facts with which it happens to be mainly conversant. Experience and observation confirm this anticipation. Every known system of law, both of ancient and modern times, in all parts of the world, and in all stages of national development, distributes itself into the main divisions of laws determining—1. The nature, functions, and limitations of the governing authority; 2. The forms and conditions of ownership, whether of land or other things; 3. The relations of family life; and 4. The binding force of voluntary promises or contracts. These several topics afford a natural method of distribution applicable to every legal system whatever; and each several topic, according to its peculiar nature and to the incidents by which it is internally characterized, affords a distinct congeries of logical subdivisions which is invariably reproduced over and over again.

It is, then, in this identity of structure of human society in every state, that law discovers for itself the basis of its constantly-recurrent methods of classification and its unchangeable conceptions. There are, however, certain other more obvious grounds for the permanence and invariability of legal ideas and methods which follow from the identity of man's physical, logical, and ethical structure in all times and in all parts of the world, within the limits to which observation has hitherto extended.

Law in its outward character consists of a body of commands addressed to individual members of the human race forming the component elements of a state. The issuing of commands involves the possibility of obedience or of disobedience, and therein supposes the presence of will, of liberty of action, and of the amount of intelligence needed to understand the purport of the commands. Attention is thereby compelled to the exceptional cases in which the terms of the command cannot be understood, whether through temporary incapacity, as infancy, error, or passing disease; or through permanent incapacity, as life-long insanity; or in which the terms cannot be complied with, through the pressure of external force, the interference of persons actuated by fraudulent motives, or the obstruction of physical facts creating the condition of impossibility.

Supposing, however, that the command can be understood and can be obeyed, there will be nevertheless cases presented in which the question has to be decided whether, as a matter of fact, the command, in a given case, was obeyed or not. Here are let in all the obstacles inherent in human nature itself to acquiring a correct knowledge of facts. All the current imperfections of human observation, all the insufficiency of language and expression, all the chicanery and double-mindedness, all the dullness of intellect, by which it becomes so hard to pass truth on unimpaired from hand to hand, are present to hamper the effort to apply and execute a single law. The several forms of these obstacles, however, are not peculiar to any one state nor to any one period, however their magnitude may vary. They are universally present, and can be classified under a comprehensive scheme.

But another and universal class of difficulties in executing a law has yet to be mentioned. It may be uncertain what are the form and intent of the law itself. If the law is written, the terms of the language in which it is written may admit of all sorts of ambiguity or vacillation in meaning, or, however certain the terms themselves, the opposed disputants may insist on different senses being put upon the whole text of the command.

If the law is unwritten, and has to be gathered either from traditional report or by reference to the rules which have been laid down on previous occasions in cases resembling the one now calling for decision, opportunity is presented for all sorts of logical conflict as to the import of the previous cases cited in illustration, or as to the value of the analogies insisted upon.

In other words, a series of logical processes is involved in the *interpretation* of every law, whether written or unwritten, and the correctness of these processes may furnish ground for indefinite doubt and argument. But these logical processes are permanent and universal, and the application of them to the interpretation of law imparts their own permanence and universality to the Science of Law.

It has thus been seen that the intellectual and the ethical nature of man in all nations tends to impart a scientific character to the study of the laws by which his social actions are regulated. The physical facts of his life and bodily constitution tend to the same end. His birth, his death, his age, his liability to diseases and accidents of all sorts, his capacity of locomotion, and his several relations to time, space, quantity, measurement, and the like, further discover fresh categories into which portions of the laws which regulate his conduct, and describe his situation, under varying circumstances, in relation to his fellows, necessarily fall.

Besides the elements of the Science of Law which are discoverable within the limits of a single state, and even of the most miniature one, there are others which are developed only in the course of time, as states multiply in number, and as their relations to one another become strictly defined.

The relations of states to one another are twofold in character. Either the governments of the different states have relations to each other, or the individual citizens of the different states have relations to each other.

The first class of relations gives occasion to what is called Public International Law, and the latter to what is sometimes called, with less precision, Private International Law.

It is plain that, if the rules regulating the relations of states are true law in any sense, they are identical for all the states subject to them. The same ought to be the case with respect to the rules regulating the recognition of the laws of foreign states. But there are certain obstacles which have, in fact, prevented the uniformity of substance which might have been anticipated in this region of law.

The rules of the species of law last indicated come into being through the moral claim that is presented either by persons who, not being citizens of a given country, come to the courts of justice of that country, while sojourning there, to have rights recognized and protected which they have acquired in their own country; or by those who, being citizens of one country, but having acquired rights while sojourning in other countries, come to the courts of their own country to have those rights recognized and protected.

On every occasion for inventing rules applicable to these cases, the question is presented whether the courts of justice of a country shall recognize rights acquired either by their own citizens or by foreigners in other countries; or, in other words, whether the laws of other countries giving validity to those rights shall or shall not be held to be effectual in the courts of justice which are invited to interfere. The cases are generally further complicated by the nature of the processes and transactions out of which the asserted rights spring. Part of the transactions may have taken place in one country, and part in another, and the remedy may be sought for in a third. Or the person seeking the remedy, or against whom the remedy is sought, may be the citizen of one country, have his permanent residence or domicile in another country, and be temporarily sojourning in the country in which the remedy is sought.

It is obvious, from a mere enumeration and description of the cases which give rise to rules, that the purpose of the existence of these rules is always the facilitation of intercourse between the citizens of different states, and the prevention of practical injustice. These objects must be served in the highest degree, if the greatest possible uniformity of principle obtain in the courts of all nations in creating and applying the rules. In this way reasonable expectations are likely to be best satisfied, and fraudulent evasions of the law of any particular country are likely most effectually to be prevented. It happens, however, that, owing to the political jealousies that have have hitherto kept apart the most considerable nations of Europe, and to the foolish prejudice with which individual nations have fostered principles of law familiar in their own courts, however alien to the practice of all other countries, there have hitherto been made only very imperfect attempts at uniformity either of principle or practice in this respect.

It is probable that an increasingly clear apprehension of the logical relations of the different branches of law, whether as touching upon ownership, contract, family life, or crime, will produce the effect of assimilating the substance as well as the form of the rules of law forming the so-called Private International Law of different countries. This end is perhaps one of the most practical and desirable that the Science of Law could set before itself, though it will need at every point the aid of the Science of Legislation. This subject will be recurred to again in the chapter on Laws of Procedure.

It appears, then, from the above investigation, that there is a true Science of Law based upon the irrefragable, permanent, and invariable facts of the constitution of human society, as exhibited in the state of the physical, logical, and ethical constitution of man. The objects of the cultivation of this science are, first, the ready understanding of every system of national law, through a firm hold being obtained upon its technical structure, its topics, its logical subdivisions, and the methods of its application; secondly, an orderly view of the whole system of law of any one country in order to its comprehensive amendment, reform, and intelligent reconstruction in obedience to the needs of a new political and social era; thirdly, the attainment of a clearly expressed, rational, and well-developed system of Public International Law; and, fourthly, the reduction of the irregular, and sometimes chaotic, or arbitrary, rules of so-called Private International Law, as adopted in different states, to a uniform system, the same for all states.

THE ALLEGED ANTAGONISM BETWEEN GROWTH AND REPRODUCTION.

By Rev. ANTOINETTE BROWN BLACKWELL.

THE supposed law of inverse relations between growth and reproduction was first announced, I think, by Dr. Carpenter; but adopted independently by Mr. Spencer, whose elaborate, forcible arguments have done much to convince many physiologists that a principle so well established may be accepted without further question. But the underlying facts are so various, complex, and unsolved, it is by no means impossible, or even improbable, that some new element yet to be introduced into the premises may partially modify or even reverse the necessary logical conclusion.

The following are Mr. Spencer's main points, gathered from his "Principles of Biology," and stated in his own condensed language: "Genesis, under every form, is a process of negative or positive disintegration, and is thus essentially opposed to that process of integration which is one element of individual evolution." [1]

"When the excess of assimilative power is diminishing in such a way as to indicate its approaching disappearance, it becomes needful, for the maintenance of the species, that this excess shall be turned to the production of new individuals; since, did growth continue until this excess disappeared through the complete balancing of assimilation and expenditure, the production of new individuals would be either impossible or fatal to the parent." [2]

"We cannot help admitting that the proportion between the aggregative and separative tendencies must in each case determine the relation between the increase in bulk of the individual and the increase of the race in numbers." [3]

Up to this point one may freely admit the antagonistic relations alleged; but, when, in his article on "The Psychology of the Sexes," Mr. Spencer asserts that "a somewhat earlier arrest of individual development in women than in men is necessitated by the reservation of vital force to meet the cost of reproduction," there are so many not yet discounted conditions to be considered that the position cannot

[1] Vol. i., p. 216. [2] P. 237. [3] Vol. ii., p. 426.

be regarded as satisfactorily sustained. *There is* the "earlier arrest" of physical growth; the "rather smaller growth of the nervo-muscular system;" the much longer nutritive tax demanded for the nourishment of fœtal and infant life; the "somewhat less of general power or massiveness" in feminine mental manifestations; *there may be*, "beyond this, a perceptible falling short in those two faculties, intellectual and emotional, which are the latest products of human evolution—the power of abstract reasoning, and that most abstract of the emotions, the sentiment of justice." It does not therefore follow that these results, any or all of them, are deductions made from the "cost of reproduction." Force modified and readjusted is not force subtracted or destroyed.

The smaller nervo-muscular system, and the diminished power or massiveness of mental action, may be supposed to arise as direct results of the larger nutritive cost of maternity. But the earlier arrest of physical growth may or may not be coupled with an earlier arrest of mental development; and one or both of these may offer to us very marked illustrations—not of process prematurely cut short to be handed over to offspring—but of process quickened by other related antecedents, and therefore more rapidly completed. This need not involve loss or transfer of individual force to offspring; but, rather, a modified system of the transfer of substance and force from the environment to the reproductive functions and their products.

If it could be shown that men or women who are the parents of many children have thereby lost something of individual power, we might then be forced to admit that the greater cost related to the reproductive system in women must be at their personal expense, not at the expense of the nutriment which they assimilate and eliminate.

The weaknesses resulting from a too early or an excessive tax of functions belong to a distinct class of considerations. I assume that every balanced constitutional activity, though including loss of nutritive elements, is yet a normal aid to constitutional strength. Every action, physical or psychical, involves either integration or disintegration; every use of faculty belongs to the latter class. There is no more antagonism between growth and reproduction than between growth and thought, growth and muscular activity, growth and breathing. The antagonism is only that of action and reaction, which are but two phases of the same process—opposing phases which exist everywhere, and which must exist, or action itself cease, and death reign universally.

Growth and eating are antagonistic; yet, one must eat to live as assuredly as children must be reared at the expense of nutrition, and of still more elaborated parental force. Nor is it true that one who expends least has the most remaining. Other things being equal, the law seems to be directly reversed. One activity initiates another;

the largest individual force maintains those more active adjustments, "simultaneous and successive," between the internal and external, which indicate the most vigorous life. We must look, then, to something more than a direct antagonism, between growth and reproduction, to account for unlikenesses of the sexes in plant or animal. "The minutest organisms multiply asexually in their millions;" but "those which do not multiply asexually at all are a billion or a million times the size of those which thus multiply with the greatest rapidity;" yet these comparative rates of growth and multiplication can offer no key to any of the problems of evolution.

Mr. Spencer reasons that birds, as a class, are less in size than mammals, because they habitually expend more muscular energy in flight; and that lions, having a digestive system not superior to men, yet attain to a larger size and are more prolific, because they have a less active nervous system to sustain. Then, if women normally have equal appropriative powers with men, the surplus nutriment not needed for their smaller *physiques* may be constitutionally handed over to reproduction. Natural selection has originated an admirably complete system of related provisions to this distinct end. This fact must lead us to the conclusion that the aggregate of feminine force is the full and fair equivalent of all masculine force, physical or psychical.

The maternal constitution elaborates nutriment, from which it is itself to receive no direct benefit. But, do we forget the inexorable conditions which compel the human father to expend equivalent muscular or mental force to feed, not himself, but his dependents? Whenever man does not interfere, monogamy seems to be the general order of Nature with all higher organisms. Where the cost of obtaining food is great, the parents sustain commensurate burdens in rearing their young; and, with these claims, I think it will be found that monogamy is the primal condition of reproduction. The warlike duty of defense is also borne chiefly by males, and must often be an immense tax on the energies.

Among the beings of a lower type, plant and animal, all the more recent observations indicate that Nature herself systematically favors the females—the mothers of the destined races. Nature's sturdiest buds and her best-fed butterflies belong to this sex; her female spiders are large enough to eat up a score of her little males; some of her mother-fishes might parody the nursery-song, "I have a little husband no bigger than my thumb." Natural selection, whether the working out of intelligent design or otherwise, would make this result inevitable. We might expect that the neuter bee could be nourished into the queen-mother. If required to judge *a priori*, we should decide, if there is no predetermination of sex, that the best-fed embryos would most readily become female; since the one special fact in the feminine organism is the innate tendency to manufacture, and, within certain limits, to store up reserved force for the future needs of offspring.

In women, if there is a greater arrest of individual growth than in men, the difference begins in the fœtal life; their comparative weight and size at birth are the same as at maturity; and, if the former finish their growth earlier, it must be because relatively they grow more rapidly. The feminine circulation and respiration are both quicker; and so are the female mental processes. When the whole subject has been quantitatively investigated with sufficient exactness, I believe it will be found that, what man has gained in "massiveness," woman has gained in rapidity of action; and that all their powers of body and mind, *mathematically computed*, are, and will continue to be, real and true equivalents. The premises are already sufficiently known to compel me to this conclusion.

One point more. Physical and psychical growth in man are not arrested simultaneously. After the body has ceased to grow, the brain-system still enlarging and compacting its highly-mobile structure, mental power increases long after the more rigid, merely mechanical forces have reached their maximum. The same law applies, at least, in equal degrees to woman. If there is any proof that feminine psychical powers normally reach an earlier cessation of growth than the masculine, then, so far as I can learn, no scientist has yet collated the facts and put them before the world in evidence. On the contrary, so far is the earlier physical maturity of woman from necessitating a corresponding earlier psychical maturity, that, in the light of physiological relations, we may deduce the exactly opposite hypothesis.

In woman, maximum mental power should be reached at a considerably later period than in man, because the greater cost of reproduction, though related chiefly to the physical economy, is indirectly psychical; tending to diminish intellectual action also, and to retard its evolution. The cost of all reproductive provisions fully met, and the child-bearing age at an end, the special constitutional tendency to accumulate reserve force will not be immediately destroyed. Functions, active hitherto in the interest of posterity, go on now to accumulate in the interest of the individual. Still further, the naturally less overtaxed intellectual faculties of woman now have *this* advantage also over those of man—an advantage at least as great as the previous disadvantage.

When the vast weight of past social conditions is considered, that women thus far have failed to acquire large powers of abstract thinking and feeling, affords no reason for supposing that there is a corresponding constitutional lack of ability in this direction. They attain an earlier growth, but, that they reach the highest point even of physical vigor earlier than men, we have no evidence. Many facts indicate otherwise. Men and women live to equal ages, retain their vigor to equal ages—those using the greater force more slowly, those the lesser force more rapidly—thus with uneven steps keeping even pace in physical progress; the greater mobility of all womanly functions being less readily stiffened into inactivity. This principle, applied to the nervous system, should prolong the period of greatest mental activity, and hold the balance which measures the working value of the sexes with even justice.

Is it true that average women to-day are less versed than average men in abstract thinking, feeling, or acting? Not in New England! Not in any locality where they have equal education. They have not become *savants!* But circumstances have not yet impelled them to become such. In these days, philosophers grow by steady accretions, like every thing else. No full-armed Minerva can be expected to spring by simple heredity from a paternal Jupiter; but the laws of mental inheritance are too little known to enable us to decide that the daughters of the nineteenth century are less gifted than the sons. When women are convinced that the antagonisms between growth and reproduction, though embracing all personalities, must yet leave them all intact, every thing else may be left to adjust itself, with no solicitude for the ultimate results.

THE NOBILITY OF KNOWLEDGE.[1]

By JOSIAH P. COOKE, Jr.,

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WITHIN a comparatively few years schools for the instruction of artisans have become a prominent feature in the educational systems both of this country and of Europe, and seem destined to supersede the old system of apprenticeships. The establishment of these schools has been an important step in human progress, not because any great advantage has been gained in the cultivation of mechanical skill, but because here the future mechanic acquires culture of the mind as well as skill of the hand. Indeed, it may be doubted whether our utilitarian age can ever successfully compete with those "elder days of art" when

> "Builders wrought with greatest care
> Each minute and unseen part."

But, if our industrial schools do not make better mechanics than the workshops of the olden time, they certainly educate better men, and, by adding to skill, knowledge, they are elevating the mechanic and ennobling his calling.

If, therefore, these schools are the representatives in our age of the workshops with their bands of apprentices in the days of yore, then

[1] An address delivered before the Free Institute at Worcester, Mass., July 28, 1874.

that by which the schools are distinguished, that which they have added to the old system, is not art but mental culture; and therefore, when asked to address you on this occasion, I could think of no more appropriate subject than the Nobility of Knowledge. Identified with an institution in which mental culture is the chief aim, I felt that I was asked to address a body of cultivated working-men with whom, though employed in the mechanic arts, the acquisition of knowledge was also a privilege and a pride. I felt, moreover, that a proper appreciation of the true dignity of knowledge, in itself considered, and apart from all economical considerations, is one of the great wants of our age and of our country.

Knowledge is power. Knowledge is wealth. These trite maxims are sufficiently esteemed in our community, and need not that they be enforced by any one. So far as knowledge will yield immediate distinction or gain, it is sought and fostered by multitudes. But when the aim is low the attainment is low, and too many of our students are satisfied with superficiality, if it only glitters, and with charlatanry, if it only brings gold.

Let me not be understood to depreciate the material advantages of learning. I rejoice that in this world knowledge frequently yields wealth and fame, and I should have little hope for human progress were the prizes of scholarship less than they are. Power and wealth are noble aims, and when rightly used may be the means of conferring unmeasured blessings on mankind; but I desire at this time to impress upon you, my friends, the fact that knowledge has nobler fruits than these, and that the worth of your knowledge is to be measured not by the credits it will add to your account in the ledger or the position it may give you among men, but by the extent to which it educates your higher nature, and elevates you in the scale of manhood.

I address young men who are just entering on life, who are at an age when the mystery of our being usually presses most closely upon the soul, and whose aspirations for higher culture and clearer vision have not been deadened by the sordid damps of the world. Trust no croakers who tell you that your youthful visions are illusions, which a little contact with the real business of the world will dispel. It is only too true that these visions will become fainter and fainter, if you allow the cares of the world to engross your thoughts; but, unless your higher nature becomes wholly deadened, you will look back to the time when the visions were brightest, as the golden period of your life, and let me assure you that, if you only are true to the aspirations of your youth, they will become clearer and clearer to the last, and, as we firmly believe, will prove to be the dawn of the perfect day.

My friends, if you have seen these visions, "the nobility of knowledge" has been a reality of your experience. You know that there is a life lived in communion with the thoughts of great men or with the thoughts of God as we can read them in Nature and Revelation, which is purer and nobler than a life of money-making or political intrigue, and I would that I could so bring you to appreciate not only the nobility, but also the happiness, of such a life as to induce you to try to live it. Do you tell me that it is only granted to a few men to become scholars, and that you have been educated for some industrial pursuit? But remember, as I said before, that it is your special privilege to have been educated, to have added knowledge to your handicraft, and that this very knowledge, if kept alive so far as you are able, will ennoble your life. Knowledge, like the fairy's wand, ennobles whatever it touches. The humblest occupations are adorned by it, and without it the most exalted positions appear to true men mean and low.

Nor is it the extent of the knowledge, alone, which ennobles, but much more the spirit and aim with which it is cultivated, and that spirit and aim you may carry into any occupation however engrossing, and into any condition of life however obscure.

And let me add that what I have said is true not only of the individual, but also, and to an even greater degree, of the nation. Our people, for the most part, look upon universities and other higher institutions of learning as merely schools for recruiting the learned professions, and estimate their efficiency solely by the amount of teaching-work which they perform. But, however important the teaching function of the university may be, I need not tell you that this is not its only or chief value to a community. The university should be the centre of scientific investigation and literary culture, the nursery of lofty aspirations and noble thoughts, and thus should become the soul of the higher life of the nation. For this and this chiefly it should be sustained and honored, and no cost and no sacrifice can be too great, which is required to maintain its efficiency. And its success should be measured by the amount of knowledge it produces rather than by the amount of instruction it imparts.

Harvard College, by cherishing and honoring the great naturalist she has recently lost, has done more for Massachusetts than by educating hosts of commonplace professional men. The simple title of teacher, which in his last will Louis Agassiz wrote after his name, was a nobler distinction than any earthly authority could confer; but remember he was a teacher not of boys, but of men, and his influence depended not on the instruction in natural history which he gave in his lecture-room, but on his great discoveries, his far-reaching generalization, and his noble thoughts. Although that man died poor, as the world counts poverty, yet the bequest which he left to this people cannot be estimated in coin.

It is a sorry confession to make, but it is nevertheless the truth, that, if we compare our American universities, in point of literary or scientific productiveness, with those of the Old World, they will appear lamentably deficient. Let me add, however, that this deficiency arises not from any want of proper aims in our scholars, but simply from the circumstance that our people do not sufficiently appreciate the value of the higher forms of literary and scientific work to bear the burden which the production necessarily entails. Scholars must live, as well as other men, and in a style which is in harmony with their surroundings and cultivated tastes, and their best efforts cannot be devoted to the extension of knowledge unless they are relieved from anxiety in regard to their daily bread.

In our colleges the professors are paid for teaching and for teaching only, while in a foreign university the teaching is wholly secondary, and the professor is expected to announce in his lectures the results of his own study, and not the thoughts of other men. Until the whole status of the professors in our chief universities can be changed, very little original thought or investigation can be expected, and these institutions cannot become what they should be, the soul of the higher life of the nation. It is in your power, however, to bring about this change, but the reform can be effected in only one way. You must give to your universities the means of supporting fully and generously those men of genius who have shown themselves capable of extending the boundaries of human knowledge, and demand of them, *only*, that they devote their lives to study and research, and let me assure you that no money can be spent which will yield a larger or more valuable return.

If you do not look beyond your material interests, the higher life of the nation, which you will thus serve to cherish and foster, will guard your honor, and protect your home; and, on the other hand, what can you expect in a nation whose highest ideal is the dollar, or what the dollar will buy, but venality, corruption, and ultimate ruin?

But, rising at once to the noblest considerations, and regarding only the welfare of your country and the education of your race, what higher service can you render than by sustaining and cherishing the grandest thought, the purest ideals, and the loftiest aspirations, which humanity has reached, and making your universities the altars where the holy fire shall be kept ever burning bright and warm?

Do you think me an enthusiast? Look back through history, and see for yourselves what has made the nations great and glorious. Why is it that, after twenty centuries, the memory of ancient Greece is still enshrined among the most cherished traditions of our race? Is it not because Homer sang, Phidias wrought, and Plato, Aristotle, Demosthenes, Thucydides, with a host of others, thought and wrote? Or, if for you the military exploits of that classic age have the greater charm, do not forget that, were it not for Grecian literature, Thermopylæ, Marathon, and Salamis, would have been long since forgotten, and that the bravery, self-devotion, and patriotism, which these names embalm, were the direct fruits of that higher life which those great thinkers illustrated and sustained. And, coming down to modern times, what are the shrines in our mother-country which we chiefly venerate, and to which the transatlantic pilgrim oftenest directs his steps? Is it her battle-field, her castles and baronial halls, or such spots as Stratford-on-Avon, Abbotsford, and Rydal Mount? Why, then, will we not learn the lesson which history so plainly teaches, and strive for those achievements in knowledge and mental culture which will be remembered with gratitude when all local distinctions and political differences shall have passed away and been forgotten?

While I was considering the line of discourse which I should follow on this occasion, an incident occurred suggesting an historical parallel, which will illustrate, better than any reflections of mine, the truth I would enforce. The ship Faraday arrived on our coast after laying over the bed of the Atlantic another of those electric nerves through which pulsate the thoughts of two continents, and, as I read the description of that noble ship, fitted out with all the appliances which modern science had created to insure the successful accomplishment of the enterprise, I remembered that not a century had elapsed since the first obscure phenomena were observed, whose conscientious study, pursued with the unselfish spirit of the scientific investigator, had led to these momentous results, and my imagination carried me back to an autumn day of the year 1786, in the old city of Bologna, in Italy, and I seemed to assist at the memorable experiment which has associated the name of Aloysius Galvani with that mode of electrical energy which flashes through the wire-cords that now unite the four quarters of the globe.

Galvani is Professor of Anatomy in the University of Bologna, and there is hanging from the iron balcony of his house a small animal preparation, which is not an unfamiliar sight in Southern Europe, where it is regarded as a delicacy of the table. It is the hind-legs of a frog, from which the skin had been removed, and the great nerve of the back exposed. Six years before, his attention had been called to the fact that the muscles of the frog were convulsed by the indirect action of an electrical machine, under conditions which he had found very difficult to interpret. He had connected the phenomenon with a theory of his own: that electricity—that is, common friction electricity, the only mode of electrical action then known—was the medium of all nervous action; and this had led him into a protracted investigation of the subject, during which he had varied the original experiment in a thousand ways, and he had now suspended the frog's legs to the iron balcony, in order to discover if atmospheric electricity would have any effect on the muscles of the animal.

Galvani has spent a long day in fruitless watching, when, while holding in his hand a brass wire, connected with the muscles of the frog, he rubs the end, apparently listlessly, against the iron railing, when, lo! the frog's legs are convulsed.

The patient waiting had been rewarded, for this observation was the beginning of a line of discovery which was ere long to revolutionize the world. But Galvani was not destined to follow far the new path he had thus opened. The remarkable fact observed was this: The convulsions of the frog's legs could be produced without the intervention of electricity, or, at least, of the one kind of electricity then known, and Galvani soon found out that the only condition necessary to produce the result was, that the nerve of the frog should be connected with the muscle of the leg by some good electrical conductor. But, although Galvani followed up this observation with the greatest zeal, and showed remarkable sagacity throughout his whole investigation, yet he was too strongly wedded to his own theory to interpret correctly the facts he observed. He supposed, to the end of his life, that the whole effect was caused by animal electricity flowing through the conductor from the nerve to the muscle, and his experiments were chiefly interesting to himself and to his contemporaries, from the light they were supposed to throw on the mysterious principle of life. We now know that animal electricity played only a small part in the phenomena he observed, and that the chief effects were due to a cause of which he was wholly ignorant.

Galvani published his observations in 1791, in a monograph entitled "The Action of Electricity in Muscular Motion." This publication excited the most marked attention, and, within a year, all Europe was experimenting on frogs' legs. The phenomena were everywhere reproduced, but Galvani's explanation of the phenomena was by no means so universally accepted. His theory was controverted in many quarters, and by no one more successfully than by Alexander Volta, Professor of Physics in the neighboring University of Pavia. Volta, while admitting, with Galvani, that the muscular contractions were caused by electricity, explained the origin of the electricity in a wholly different way. According to Volta, the electricity originated not in the animal, but in the contact of the dissimilar metals, or other materials used in the experiment. This difference of opinion led to one of the most remarkable controversies in the history of science, and for six years, until his death in 1798, Galvani was occupied in defending his theory of animal electricity against the assaults of his distinguished countryman.

This discussion created the liveliest interest throughout Europe. Every scholar of science took sides with one or the other of these eminent Italian philosophers, and the scientific world became divided into the school of Galvani and the school of Volta. Yet, so far at least as the fundamental experiment was concerned, both were wrong. The electricity came neither from the body of the frog nor from the contact of dissimilar kinds of matter, but was the result of chemical action, which both had equally overlooked. But, nevertheless, the controversy led to the most important results: for Volta, while endeavoring to sustain his false theory by experimental proofs, was led to the discovery of the *voltaic* pile, or, as we now call it, the *voltaic* battery, an instrument whose influence on civilization can be compared only with the printing-press and the steam-engine. Yet, although the whole action of the battery was in direct contradiction to his pet theory, still, to the last, Volta persistently defended the erroneous doctrine he had espoused in his controversy with Galvani thirty years before, and he died in 1827, without realizing how great a boon he had been instrumental in conferring on mankind; so true it is, that Providence works out her bright designs even through the blindness and mistakes of man.

But there is another lesson to be learned from this history, which cannot be too often rehearsed in this self-sufficient age, which boasts so proudly of its practical wisdom. There were, doubtless, many practical men in that city of Bologna to smile at their sage professor who had spent ten long years in studying, to little apparent purpose, the twitchings of frogs' hind-legs, and there was many a jest among the courtiers of Europe at the expense of the learned philosophers who "wasted" so much time in discussing the cause of such trivial phenomena. But how is it now?

Less than a century has passed since Galvani's death; and, in a small hut, on the shores of Valentia Bay, may be seen one of the most skillful of a new class of *practical men*, representing a profession which owes its origin to Galvani and Volta. This *electrician* is watching a spot of light on the scale of an instrument which is called a *galvanometer*. Since the fathers fell asleep, the field of knowledge which they first entered has spread out wider and wider before the untiring explorers who have succeeded them. Oersted and Seebeck, Arago and Ampère, Faraday and our own Henry, have made wonderful discoveries in that field; and other great men, like Steinheil, Wheatstone, Morse, and Thomson, have invented ingenious instruments and appliances, by which these discoveries might be made to yield great practical results.

The spot of light, which the electrician is watching, is reflected from one of the latest of these inventions—the reflecting galvanometer of Thomson. He and his assistants had been watching by turns the same spot for several days, since the Great Eastern had steamed from the bay, paying out a cable of insulated wire. These electricians had no anxiety as to the result, for daily signals had been exchanged between the ship and the shore, as hundreds after hundreds of miles of this electrical conductor had been laid on the bed of the broad ocean. The coast of Newfoundland had already been reached, and they were only waiting for the landing of the cable at the now far-distant end.

At length the light quivers, and the spot begins to move! It answers to concerted signals! And soon the operator spells out the joyful message. The ocean has been spanned with an electric nerve, and the New World responds to the greetings of the Old.

Here is something practical, which all can appreciate, and all are ready to honor. We honor the courage which conceived, the skill which executed, and, above all, the success which crowned the undertaking. But, do we not forget that professor of Bologna with his frogs' legs, who sowed the seed from which all this has sprung? He labored without hope of temporal reward, stimulated by the pure love of truth; and the grain which he planted has brought forth this abundant harvest. Do we not forget, also, that succession of equally noble men, Volta, and Oersted, and Faraday, with many other not less devoted investigators of electrical science, without whose unselfish labors the great result never could have been achieved? Such men, of course, need no recognition at our hands, and I ask the question not for their sakes, but for ours. The intellectual elevation of the lives they led was their all-sufficient reward.

It is, however, of the utmost importance for us, citizens of a country with almost unlimited resources, that we should recognize what are the real springs of true national greatness and enduring influence. In this age of material interests, the hand is too ready to say to the head, "I have no need of thee," and, amid the ephemeral applause which follows the realization of some triumph over matter, we are apt to be deceived, and not observe whence the power came. We associate the great invention with some man of affairs who overcame the last material obstacle, and who, although worthy of all praise, probably added very little to the total wealth of knowledge, of which the invention was an immediate consequence; and, not seeing the antecedents, we are apt to underrate the part which the student or scientific investigator may have contributed to the result.

It is idle, for example, to speak of the electric telegraph as invented by any single man. It was a growth of time; and many of the men who contributed to win this great victory of mind over space "builded far better than they knew." As I view the subject, that invention is as much a gift of Providence as if the details had been supernaturally revealed. But, whatever may be our speculative views, it is of the utmost importance to the welfare of our community that we should realize the fact that purely theoretical scientific study, pursued for truth's sake, is the essential prerequisite for such inventions. *Knowledge is the condition of invention.* The old Latin word *invenio* signifies *to meet with*, or *to find*, and these great gifts of God are *met with* along the pathway of civilization; but the throng of the world passes them unnoticed, for only those can recognize the treasure whose minds have been stored with the knowledge which the scholar has discovered and made known.

If, then, as no one will deny, science and scholarship are the powers by which improvements in the useful arts are made, I might appeal to your self-interest to support and cherish them. But I should despise myself for appealing to such a motive, and you for requiring it. The supreme importance of science and scholarship to a nation does not depend in the least on the circumstance that important practical results may follow. When, as in the case of Galvani's frogs, they come in the order of Providence, let us thank God for them as a gift which we had no right either to expect or demand. Science, if studied successfully, must be studied for the pure love of truth; and, if we serve her solely for mercenary ends, her truths, the only gold she offers, will turn to dross in our hands, and we shall degrade ourselves in proportion as we dishonor her. Galvani, and Volta, and Oersted, who discovered the truths of which the electric telegraph is a simple application, sure to be made as soon as the time was ripe, are not the less to be honored because they died before the fullness of that time had come. We honor them for the truths they discovered, and the lustre of their consecrated lives could be neither enhanced nor impaired by subsequent events; and it is because I am persuaded that such lives are the salt of the world, the saviors of society, that I would lead you to cherish and sustain them; and, that I may enforce this conclusion, allow me to ask your attention to another historical incident, which presents a striking parallelism to the last.

I must take you back to a period which we, of a nation born but yesterday, regard as distant, but which was one of the most noted epochs of modern history—the age of Luther and the Reformation. I must ask you to accompany me to the small town of Allenstein, near Frauenberg, in Eastern Prussia, where, on the 23d of May, 1543, there lay dying one of the great benefactors of mankind. This man, old at seventy years, "bent and furrowed with labor, but in whose eye the fire of genius was still glowing," was then known as one of the most learned men of his time. Doctor of Medicine as well as of Theology, Canon of Frauenberg, Honorary Professor of Bologna and Rome, while devoting his leisure to study, he had passed a life of active benevolence in administering to the bodily as well as the spiritual wants of the ignorant people among whom his lot had been cast. He was also a great mechanical genius, and, by various labor-saving machines, of his own invention, he had contributed greatly to the welfare of the surrounding country; but the superstitious peasants, although they had hitherto reverenced the great man as their best friend and benefactor, had been recently incited by his enemies and rivals in the Church to curse him as a heretic and a wizard. A few days back he had been the unwilling witness of one of those out-of-door spectacles, so common at that time, in which his scientific opinions had been travestied, his charities ridiculed, and his devoted life made the object of slander and reproach. This ingratitude of his flock had broken his heart, and he could not recover from the blow.

The occasion of this outburst of fanaticism was the approaching publication of a work in which he had dared to question the received opinions of theologians and schoolmen, in regard to cosmogony. He had, forsooth, denied that the visible firmament was a solid azure-colored shell, to which the sun and planets were fastened, and through whose opened doors the rain descended. He had proved that the sun was the centre of the system, around which the earth and planets revolved, and, with his clear scientific vision, he had been able to gain glimpses, at least, of the grand conceptions of modern astronomy: For this man was Nicolas Copernicus, and the expected book was his great work—"De Orbium Cœlestium Revolutionibus"—destined to form the broad basis of astronomical science. The work was printing at Nuremberg, and the last proofs had been returned; but reports had come that a similar outburst of fanaticism was raging at that place, that a mob had burnt the manuscript on the public square, and had threatened to break the press should the printing proceed. But, thanks to God! the old man was not to die before the hour of triumph came. While still conscious, a horse, covered with foam, gallops to the door of his humble dwelling, and an armed messenger enters the chamber, who, breathless with haste, places in the hands of the dying man a volume still wet from the press. He has only strength to return a smile of recognition, and murmur the last words:

"Nunc dimittis servum tuum, Domine."

Grand close of a noble life! The seed has been sown—what could we desire more?

Again the centuries roll on—not one, but three; while the seed grows to a great tree, which overshadows the nations. Great minds have never been wanting to cherish and prune it, like Tycho Brahe and Kepler, Galileo and Newton, Laplace and Lagrange; and although at times some, while lingering in the deep shade of the foliage, may have lost sight of the summit, the noble tree has ever pointed upward to direct aspiration and encourage hope.

On the evening of the 24th of September, 1846, in the Observatory of Berlin, a trained astronomical observer was carefully measuring the position of a faint star in the constellation Capricorn. Only the day before, he had received from Le Verrier a letter announcing the result of that remarkable investigation which has made the name of this distinguished French astronomer so justly celebrated. By the studies of the great men who succeeded Copernicus, his system had become so perfected as to enable the astronomer to predict, with unerring certainty, the paths of the planets through the heavens. But there was one failing case.

The planet Uranus, then supposed to be the outer planet of the solar system, wandered from the path which theory assigned to it; and although the deviations were but small, yet any discrepancy between theory and observation in so accurate a science as astronomy could not be overlooked. Long before this, the hypothesis had been advanced that the deviations were caused by the attractive force of an unseen and still more distant planet; but, as no such planet had been discovered, the hypothesis had remained until now wholly barren. The hypothesis, however, was reasonable, and furnished the only conceivable explanation of the facts; and, moreover, if true, the received system of astronomy ought to be able to assign the position and magnitude of the disturbing body, the magnitude and direction of the displacements being given.

This possibility was generally appreciated by astronomers, and the very great length and difficulty of the mathematical calculation which the investigation involved was probably the reason that no one had hitherto undertaken it. Le Verrier, however, had both the courage and the youthful strength required for the work. And now the great work had been done; and, on the 18th of September, Le Verrier had sent to the Observatory of Berlin his communication announcing the final result, namely, that the planet would be found about 5° to the east of the star Delta of Capricorn.

The letter containing this announcement was received by Galle, at Berlin, on the 23d, and it was Galle whom we left measuring the position of that faint star on the evening of the 24th. It so happened that a chart of that portion of the heavens had recently been prepared by the Berlin Observatory, and was on the eve of publication; and, on the very evening he received the letter, Galle had found, near the position assigned by Le Verrier, a faint star, which was not marked on this chart. The object differed in appearance from the surrounding stars, but still it was perfectly possible that it might be a fixed star which had escaped previous observation.

But, if a fixed star, its position in the constellation would not vary, while, if a planet, a single night would show a perceptible change of place. Hence, you may conceive of the interest with which Galle was measuring anew its position on the evening of the 24th.

The star had moved, and in the direction which theory indicated; and for once, at least, the world rang with applause at a brilliant scientific conquest, from which there was not one cent of money to be made. Yet, was that conquest any the less important to the world? What had it secured? It had confirmed the theory of astronomy which Copernicus and his successors had built up, and it had clinched the last nail in the proof that those grand conceptions of modern astronomy, now household thoughts, are realities, and not dreams. Certainly no military conquest can compare with this.

Do you smile at the enthusiasm which rates so high a purely intellectual achievement? Go out with me under the heavens, in some starlit night, and, looking up into the depths of space, recall the truths you have learned in regard to that immensity, and allow the imagination free scope as it stretches out into the infinitudes of time, space, and power, carrying the mind on, bound by bound, through the limitless expanse, until even the imagination refuses to follow, and fairly quails before the mighty form of the Infinite, which rises to confront it! Remember now that your forefathers, of only a few centuries back, saw there nothing but a solid dome hemming in the earth and skies, and that you are able to look upon this grand spectacle only because great minds have lived who have opened your intellectual eyes; and then answer me, is not this result worth all the labor, all the sacrifice, all the treasure, it has cost?

Every educated man, who has not sold his birthright for a mess of pottage, lives a grander and a nobler life, because the great astronomers have thought and taught, and this elevation of human life is the greatest achievement of which man can boast. Before it all material conquests appear of little worth, and the lustre of all military or civil glory grows dim. Cherish this intellectual life; foster it; sustain it; do what you can by your own spirit and influence, and, if you are blest with riches, give of your abundance to support and encourage those who, by genius, talent, and devotion, will widen the intellectual kingdom. Be assured you will thus help to confer an inestimable boon on your race and on your country; and the influence for good will not be felt by the *intellectual* life of the nation only; that corruption which is now festering at the heart of our body politic, and threatening its destruction, can in no way be fought and conquered so effectually as by keeping constantly before the nation noble and high ideals; for, where the higher life is cherished and honored, the mercenary and sensual motives of action, which both invite and shield corruption, lose much of their force and power.

But you may tell me that there is a life higher than the intellectual life, and that I have ascribed to science and scholarship influences which come only from a source which I have forgotten, or left out of view. My friends, all truth is one and inseparable, and I have therefore made no distinction in this address between the truths of science and the truths of religion. That grand old word knowledge, as I have used it, includes both, and in just the proportion that you reverence religion, you must reverence also true science. All truth is God's truth, and, in praying for the coming of his kingdom, you certainly do not expect that Nature will be divorced from Grace. If the truths of religion required a special revelation, it must be expected that they would transcend human intelligence. These very conditions imply conflict, but the conflict comes not from the knowledge, but from the ignorance and conceit of men; and the only proper attitude for the devout scholar is 'to labor and to wait.' And what more wonderful confirmation could we have of the essential unity of the two phases of truth than is to be found in the fact that the characteristic of science, which I have been endeavoring to illustrate in this address, is the great prominent feature of Christianity. Christianity was revealed in a life, and ever abides a life in the soul of man, to purify, ennoble, and redeem humanity.

"And so the Word had breath, and wrought,
With human hands, the creed of creeds,
In loveliness of perfect deeds,
More strong than all poetic thought—

"Which he may read that binds the sheaf,
Or builds the house, or digs the grave,
And those wild eyes that watch the wave,
In roarings round the coral-reef."

SKETCH OF DR. J. L. LE CONTE.

THIS gentleman was elected, at the Portland meeting, last year, President of the American Association for the Advancement of Science for 1874, and will preside at the twenty-third session, to be held at Hartford, Conn., commencing August 12th. He belongs to a family that has made itself distinguished in American science, mainly in the direction of natural history and geology, his own chosen field of inquiry having been chiefly that of entomology.

JOHN L. LE CONTE was born in New York, on May 13, 1825. His father, Major John Eatton Le Conte, formerly of the U. S. Army, possessed broad culture both in science and literature, and was well known among the early botanists and zoologists of the country.

The family is descended from a Huguenot of noble birth, who emigrated to New York in consequence of the religious and political persecutions which followed the revocation of the Edict of Nantes. Major Le Conte and his brother Louis were close students and accurate observers, almost from the beginning of the century, though the extreme diffidence of the latter, added to the want of proper channels for publication, prevented him from contributing to the literature of science. Two of the sons of Louis Le Conte, John and Joseph, formerly of Georgia and South Carolina, but now of the University of California, have made many valuable additions to physics and geology.

The subject of the present sketch was inspired, at an early age, by the example and teaching of his father, with a strong passion for science. After an academic course at Mt. St. Mary's College in Maryland, where he graduated in 1842, he studied medicine at the College of Physicians and Surgeons, in New York, receiving his diploma in 1846. The intervals between the courses, and other times later in life, were occupied in extensive journeys in the United States, for the purpose of making collections in natural history, upon one branch of which, the *Coleoptera* of North America, he gradually concentrated his attention, while still retaining his interest and endeavoring, by books, to keep up his knowledge of collateral subjects.

In 1852 Major Le Conte and his son removed from New York to Philadelphia, which, on account of the greater activity in science then existing, was believed by them to offer, by its libraries, collections, and personal associations, better facilities for study.

The survey of the Interoceanic-Railway route across Honduras, by Mr. J. C. Trautwine, gave Dr. Le Conte an opportunity of spending a few months in the tropics in 1857; and a short memoir, on the economic geology of the State, from his pen, is contained in the final report of the survey, printed in London. Another, on the famous "Fuente de Sangre," will be found in the appendix to the second work of Hon. E. G. Squier, on Central America, solving the mystery of that singular phenomenon.

During the late civil war he entered the army medical corps as surgeon of United States volunteers, and, on the occurrence of a vacancy, was promoted to the grade of Lieutenant-Colonel and Medical Inspector U. S. A., in which capacity he served until the mustering out of the inspectors after the close of the war, in 1865.

The cessation of official duties enabled him again to resume his scientific pursuits, the results of which continue to be published in scientific magazines and transactions of learned societies.

The survey for the extension of the Kansas Pacific Railway under General W. W. Wright, in 1867, enabled him to visit a portion of Colorado and New Mexico. Some new observations on the geological structure of the regions adjacent to the route surveyed will be found in the report which he then prepared.

His contributions to the study of North American *Coleoptera* are very numerous; for their titles, the "Bibliographia" of Dr. Hagen, and the annual reports on the progress of entomology, must be referred to. A compendium of the arrangement adopted by him may, however, be found in the classification of the *Coleoptera* of North America, Smithsonian "Miscellaneous Collection," 8vo.

As an evidence of the general appreciation of his memoirs, he has been elected honorary member of many foreign and domestic scientific societies, and correspondent of a still larger number.

CORRESPONDENCE.

CURIOUS ACTION OF MUCILAGE ON GLASS.

THE article on "The Action of Sunlight on Glass," published in THE POPULAR SCIENCE MONTHLY for May, has elicited from Dr. F. Hollick, of this city, inquiries concerning the large plate-glass window of 104 Broadway, which is very much disfigured. Dr. Hollick says: "A 'Notice' was written on a piece of common brown paper, and pasted on the inside of the window with ordinary mucilage. On removing this 'Notice,' it was observed that the mucilage did not come off clean. Water, alcohol, and various other solvents, were employed, but all to no purpose, the glass remaining dim wherever the mucilage had been applied; the fact was, as was evident on inspection, that the surface of the glass was corroded, as if it had been acted upon by fluoric acid; and, what is more singular still, this corrosion has been extending ever since, till it now covers a large space. There seems to be a process of disintegration, or molecular change going on, which bids fair to destroy, in time, the whole pane. Now, the question comes, What is the nature of this change, and how was it started? The paper was of the ordinary brown wrapping kind, and the mucilage such as is in common use, and which has no action upon the bottle which contains it."

In reply to this inquiry, Mr. Thomas Gaffield, of Boston, writes:

To the Editor of the Popular Science Monthly.

SIR: A few days ago I received from a gentleman in New York some pieces of a large pane of plate-glass, taken from a window on Broadway, upon which had been affixed, with common mucilage, a notice written upon brown paper. When this notice was removed in about forty-eight hours, it was found that the portion of the surface covered by the mucilage was roughened, and presented an appearance of little hollows, or pits, from which the glass had been actually torn away by the washing or tearing off of the brown paper.

My informant says that some workmen passing by noticed the injured glass, and went in to examine it, stating that they had removed two other panes for the same defect. At the same time, experiments on other glass with similar paper and mucilage had led to no similar results, showing that all glasses are not so affected. My correspondent is surprised at what he has noticed, and desires an explanation of the cause. I will give my humble suggestions on the matter, and let others with more scientific knowledge enjoy the same privilege.

Let me at first, however, give a brief account of a few similar but very rare occurrences; for, though my New York friend names a fact not often noticed in the books, yet it is another illustration of the old saying, that "there is nothing new under the sun."

While spending some time, in 1862, in looking over the "Transactions" of the English and French scientific associations for one or two past centuries, I found the following very interesting item in the "Histoire de l'Académie," for 1708, page 22:

"EXFOLIATED GLASS.

"A person having applied to a piece of glass, about six inches square, a paste of Spanish white and glue size, placed the whole in the sun, during the great heat of summer. The paste, which was turned toward the sun, having been heated, rolled itself up, so that, in its movement, its under side was raised upward. But, what was more singular, this surface raised with it, and carried away, a layer of the glass. This layer made on the paste a species of varnish, as of porcelain, the thickness not exceeding one-half a line. It was astonishing that the adherence of the paste to the glass was so strong; and equally so, that it should be able to detach from the glass so considerable a sheet. It had been blown, and apparently they had replunged the pipe, with which it was blown, in the crucible at different times, which had given it several layers, which, however, were not apparent, because they were exactly applied one upon another. It is to Geoffroy that we owe this observation."

This was the only item of the kind which I ever found in the old books, and I had my doubts of its accuracy, until I read, in the London *Photographic News* of July 17, 1868, the following article:

"CURIOUS EFFECT OF GELATINE UPON GLASS.

"A correspondent sends us the following account of a curious result:

"Having, for experimental purposes, poured a thick solution of gelatine upon a number of glass plates, three of them were set aside upon a shelf for some months; and one day, upon looking at them, I found that, in all three cases, the gelatine had separated from the glass, bringing away the whole surface of the glass plates in shivers, which firmly adhered to the gelatine. The surface of the glass was left full of ruts, like water-worn stones. I suppose it to be caused by the strong contraction of the gelatine, and its firm hold upon the glass."

I wrote a short notice of these two similar facts for the Philadelphia *Photographer*, of November, 1868.

Singularly enough, just after this date, while experimenting in making my "photographic self-prints from Nature" (an account of which I have sent you in my little pamphlet), I noticed a similar phenomenon.

You will recollect that I place leaves and ferns upon glass with mucilage, and print their forms upon sensitive paper by exposure to the sunlight. After the ferns are dried up, I clean the glass for further use. In washing one of these glasses, it was impossible to make the surface perfectly clean. On a close examination, I found that, in removing the ferns and mucilage, the latter had taken off a portion of the glass, so that I could distinctly observe, on the crowded surface, the outlines of an anchor (which was the figure produced), and the forms of some of the individual ferns. I have this curious specimen—not of plate, but of sheet glass—in my cabinet, and will show it to you or any of your correspondents who may call on me.

There are numerous very interesting thoughts and queries suggested by the various and yet similar incidents referred to above. In making sheet window-glass, the workman makes three, and, for very thick glass, four gatherings upon his blow-pipe, creating, as suggested, three or four layers in the finished pane of glass, although not visible to the naked eye. Some workmen reheat the glass after the last gathering, in order, by what is called "burning over," to make the heated ball more uniform and homogeneous. The glass is then more easily and perfectly annealed, and more easily and safely cut by the diamond. The sheet-glass, named in the curious incidents related above, was probably of a kind not "burnt over" and perfectly homogeneous, and, for this reason, more easily disintegrated by the strong adhesive and contracting power of the gelatine and mucilage, overcoming the cohesion of the atoms and layers of the glass.

While crown and sheet glass have an original fine surface, that of plate-glass is softer and more easily affected, because it is an artificial one, which has been subjected to the three successive operations of the grinding, smoothing, and polishing machines.

The above explanation supposes mechanical action only. But, it is possible, a chemical action took place also, especially in the plate-glass, in the formation of some acid, by the fermentation of the gelatine or mucilage, when under the influence of sunlight or the atmosphere. The glasses all contained alkali, in the form of soda or potash, and perhaps some uncombined alkali, which might have formed a chemical combination with the acid of the mucilage, and so corroded or disintegrated the surface of the glass. The effect observed was, undoubtedly, the result of both mechanical and chemical action.

I found, on inquiry of several dealers in chemicals, that mucilage frequently contains acetic acid or alum, to prevent the formation of mould. In such cases, the acetic acid might easily form a chemical attachment, under the warming influence of the sun's rays, for some of the constituents of the glass, creating acetate of soda, of potash, or of iron.

Alum (which is a compound of sulphate of alumina and sulphate of potash), under the same influence, might be subject to the chemical interchange called isomorphism, giving up its potash for some of the soda in the glass. These new compounds, if soluble in water, would be removed in washing off the mucilage, or, if insoluble, would be torn away when pulling off the paper attached by the adhesive gum.

In view of these facts, it would be well not to run the risk of possible injury to any of our valuable windows by affixing notices upon them with mucilage.

My correspondent thinks he noticed a continued or increasing corrosion, or disintegration, of the surface of the plate-glass after the removal of the mucilage. On examination of one of the pieces sent to me, I found a discoloration, occasioned by what we call "rust," in a part not affected by the mucilage, and this was probably what our friend observed.

There are glasses sometimes made with an excess of uncombined alkali which effloresces upon the surface, sometimes before it is placed in the window, and sometimes at a later period. This, of course, causes a series of infinitesimal holes or furrows in the glass, whose surface by the reflection and refraction of the rays of light presents, like the mother-of-pearl, all the colors of the rainbow when held in a certain position, and at the right angle for such effect. This is one kind of what is called stained or rusty glass. In other specimens the disintegration goes beyond the infinitesimal character and is plainly visible, making the glass appear as if fire-cracked, and in its ultimate effect producing the appearance, on one or both surfaces, of ground glass.

In one of these stages of rust or disintegration I find a piece of the glass referred to by my correspondent.

In reference to the matter of rust on glass, for the comfort of my readers and of my New York friends who are dealers in window-glass (which was my business for many years), let me say that this difficulty or defect is not an every-day trouble, but only one of the incidents or curiosities of glass-making. A good glass-maker knows how to avoid it, and a good glass-dealer can, in many instances, remove the first appearance of rust or stain on plate or sheet glass by a skillful and nimble use of dilute hydro-fluoric acid and rouge or oxide of iron.

Glass-making and glass-dealing have their troubles, and this of occasional rust on glass is one. But all other kinds of business have their trials, and they all have their points of interest and satisfaction. In the study necessary to remove troubles and avoid mistakes, comes half the pleasure of life. If we had no obstacle in the path of our business, we ourselves would rust out.

In closing my article, let me add that I give my opinions only as humble suggestions, after such examination as I have been able to give to the subjects referred to.

In the light of new experiments, and the progress of scientific research by those who make it the business of life, the theories of to-day may be set aside by the revelations of to-morrow. If "an undevout astronomer is mad," so must be an undevout chemist, or student in any domain of natural science, who will not humbly bow before the wise and wonderful workings of the Great Maker of the universe. We cannot fully understand or explain them now. We can only look "through a glass darkly." We can see and enjoy the light of the sun, but, though great and learned volumes be written, who can fully explain all the laws and all the wonders of light, one of the gentlest and most ethereal, and yet one of the most interesting and powerful elements of the universe? We must be content to labor and to wait.

BOSTON, *July* 20, 1874.

EDITOR'S TABLE.

THE DUST OF THE UNIVERSE.

THE comet has come and gone, and again raised the perplexing question as to what such bodies are made of, and what are the most subtile forms of matter diffused through the celestial spaces. Of the great moving masses which compose our own system, from the sun—1,000,000 times larger than the earth—to the little asteroids—250 miles in diameter—and from these down to the meteorites of a few pounds in weight, which strike the earth, we have become quite familiar, while spectrum analysis has carried us a long way toward the conclusion that there is a unity in the material composition of the universe. But, as every thing is in motion, and all the celestial masses are revolving and whirling at great rates of speed, and, as there is much evidence of fractures, collisions, and transformations, it seems impossible that there should not have been going on constant abrasions and comminutions, with the production of all grades of dust down to the most impalpable, as a consequence of the general wear and tear. Such a notion would, of course, have been inadmissible in old times, when people reasoned about the universe from their *a priori* notions of what it ought to be; and, holding that the heavens are the type of all perfection, they would have been shocked at the notion that the gearing of the spheres could not work without the production of dirt and dust. But we have survived those prejudices, and now search for the celestial *débris* and waste with just as much interest as we do for more imposing and dignified objects.

It is but a few years since the world was surprised and delighted by that brilliant series of researches made by Prof. Tyndall, on the formation of artificial clouds and artificial sky by the electric light, in his vacuum-tubes. Spaces, washed clean, and apparently pure, were found to be filthy with dust, and, beginning with the thinnest transparent vapors, he was able to develop a succession of the most exquisite cloud-forms definitely related to the colors of the spectrum as the molecules grew in complexity under the chemical transformation. The firmamental blue he found to be caused by impurities in the air, so attenuated as to react only with the finest waves of the ethereal medium. How far down in the scale of minuteness beyond all previous conception the particles are, which reflect the azure light of the sky, may be gathered from the following memorable passage, taken from Dr. Tyndall's "Fragments of Science" (page 148):

"From their perviousness to stellar light and other considerations, Sir John Herschel drew some startling conclusions regarding the density and weight of comets. You know that these extraordinary and mysterious bodies sometimes throw out tails 100,000,000 of miles in length, and 50,000 miles in diameter. The diameter of our earth is 8,000 miles. Both it and the sky, and a good portion of space beyond the sky, would certainly be included in a sphere 10,000 miles across. Let us fill a hollow sphere of this diameter with cometary matter, and make it our unit of measure. To produce a comet's tail of the size just mentioned, about three hundred thousand such measures would have to be emptied into space. Now, suppose the whole of this stuff to be swept together and suitably compressed, what do you suppose its volume would be? Sir John Herschel would probably tell you that the whole mass might be carted away at a single effort by one of your dray-horses. In fact, I do not know that he would require more than a small fraction of a horse-power to remove the cometary dust. After this you will hardly regard as monstrous a notion I have sometimes entertained concerning the quantity of matter in our sky. Suppose a shell to surround the earth at a height above the surface which would place it beyond the grosser matter that hangs in the lower regions of the air—say at the height of the Matterhorn or Mont Blanc. Outside this shell we have the deep-blue firmament. Let the atmospheric space beyond the shell be swept clean, and let the sky-matter be properly gathered up. What is its probable amount? I have sometimes thought that a lady's portmanteau would contain it all. I have thought that even a gentleman's portmanteau—possibly his snuff box—might take it in. And, whether the actual sky be capable of this amount of condensation or not, I entertain no doubt that a sky quite as vast as ours, and as good in appearance, could be formed from a quantity of matter which might be held in the hollow of the hand."

Whatever may be the validity of these quantitative speculations, all the lines of investigation seem to converge to the conclusion that there is such a thing as a cosmical dust, and that this form of matter, subtile as it may be, is by no means without effect in the operations of the universal scheme. The inconceivably rapid growth of the tails of comets directed away from the sun, and the mighty sweep of their movements, seem inconsistent with the direct flight or passage of cometary particles, and the effect is now rather explained on the hypothesis that matter already existing, diffused through space, may become in some way electrically polarized and rendered luminous through the mutual action of the sun and the comet. A recent writer suggests that "these polarized particles, or molecules of vapor, require time to become depolarized and to lose their luminosity, which fact may at least in part account for the breadth of the illuminated space or the apparent spread of the tail." The earth is believed to have passed through a portion of the tail of the comet of 1861. On the 30th of June its distance from the earth was rather less than 13,000,000 miles, and its train was computed to be 20,000,000 miles in length. The positions were such that it is quite possible that, on the evening of June 30th, the earth might have been involved in the tail, while certain unusual phenomena of an electrical nature were actually observed at that time. The writer on "Comets," in Brande's "Cyclopedia," says:

"It is a remarkable and significant fact that, not only in various parts of England and Ireland, but also in Spain, Italy, Switzerland, and other Continental countries, a very peculiar phosphorescence, or illumination of the sky, was perceptible during the early hours of the night in question, which many persons supposed to be caused by the aurora borealis, unusual as the phenomenon is in the summer months, especially in the south of Europe; at the same time it was remarked that the luminosity of the sky did not resemble the usual effect of the aurora, but was something quite exceptional. We incline to attribute the phenomenon to the presence of cometic matter (if matter it can be termed) in our atmosphere."

A new set of researches has recently been made known in *Poggendorf's Annalen* for March, of the present year, which seem to have a further bearing upon the problem of a universal dust. Prof. A. C. Nordenskiöld, of Stockholm, has instituted a series of investigations into the nature of the fine matter entangled and brought to the earth in great snowstorms. After one of these great storms, which occurred on December 1, 1871, he melted a quantity of the newly-fallen snow to ascertain whether it contained any solid particles. A cubic metre was thus tested, and found to contain minute traces of metallic iron and of carbon. He made a second experiment in Finland, in the midst of a large forest, and again particles of carbon and metallic iron were found. Desirous of extending his observations to widely-separated tracts, in 1872 he several times collected snow at localities north of the island of Spitzbergen with the same result—analysis showing the presence of iron, nickel, and cobalt. This dust from the snow greatly resembled a powder previously discovered by him on some islands thirty miles distant from the coast of Greenland, and was probably identical with it. The latter he has called *Krykonit*, and he was able to collect large quantities of it, and to prove that it contains *organic matter*, in addition to its other ingredients. It seems highly probable, if not indeed quite certain, that this dust, collected in the snow, is of cosmical origin, and is to be ranked with meteoric matter.

THE OXYGEN CENTENNIAL.

This event went off with great success and satisfaction, according to arrangement, July 31st and August 1st, at Northumberland, Pa., where the great discoverer spent his last days. There was an excellent representation of American chemists from all parts of the country, the exercises were spirited and appropriate, and the entire proceedings vindicated the excellent judgment of the committee who had made the arrangements.

The sessions were held in the new high-school building, and its large hall was crowded with strangers and citizens. Prof. Croft read a brief address on the character of PRIESTLEY, which was marked by a broad appreciation of his strong and many-sided traits. The subject, however, was much too large for the time given to it, and the sketch had the effect of awakening more interest than it gratified. The speaker apologized for his performance on account of the short time that had been allowed him to prepare it, and it is to be hoped that he will be enabled to give it greater fullness before publication in the volume which will embody the proceedings.

Prof. Horsford read several manuscript letters of Dr. Priestley belonging to the Massachusetts Historical Society, and not hitherto published. They were written in this country, to a friend, and are valuable as disclosing his opinions concerning questions of American politics, in which he took no public part. They were written with terseness, point, and vigor, and displayed an independence of spirit and an acuteness of observation and reflection that elicited the cordial applause of the audience who listened to them. Prof. Croft had alluded to a rumor, on the authority of the French chemist, Dumas, that Priestley died of poison; but he had been unable to find any verification or explanation of it. One of the letters read by Prof. Horsford threw light upon the matter, as Dr. Priestley wrote to his friend that the ingredient found in the flour used by the family turned out to be, not arsenic, but tartar-emetic.

Prof. Sterry Hunt gave an interesting address on the progress of theoretical chemistry since the time of Priestley, in which, after an acute and instructive analysis of the influence of Lavoisier in giving effect to Priestley's discovery and laying the foundation of modern chemical philosophy, he went on to trace the successive modifications of theory, the growth of the unitary system, and the fundamental ideas of the chemical science now generally received. Prof. Hunt's statement was deficient, in that it did not recognize the share that the speaker had himself taken in promoting the new views, but, aside from this, it was a remarkably clear and instructive presentation, in a narrow compass, of a subject not easy of popular exposition.

Dr. J. Lawrence Smith read a valuable essay on the general progress of chemistry as applied to the arts during the last hundred years, which was full of interesting information, and was listened to with close attention by a large audience. The relation of the industries of the world to the work of the laboratory was skillfully treated and vividly delineated.

In the cemetery of Northumberland, situated upon an eminence back of the town, and commanding a most beautiful view of the river and mountain scenery, rest the remains of Priestley, marked only by a simple tombstone. The strangers present in town, accompanied by many of the citizens, visited the grave at the close of the first day's proceedings, and there listened to an eloquent and appreciative eulogy of the illustrious man by President Coppee, of Lehigh University.

The public exercises were fitly concluded, on August 1st, by a most interesting address from Prof. Silliman, on the progress of chemistry in this country since the time of Priestley. The son of one of the eminent pioneers of the science on this side of the Atlantic, Prof. Silliman has been a student of the subject from his boyhood, there being, perhaps, no American more familiar with its history, or better qualified to present it. He labored under the difficulty of all the speakers, that his subject was too extensive to be treated in the time at command, and we hope that this difficulty will be amply repaired when his essay is printed, for a good history of the growth of American chemistry is much needed. The effect of the centennial contributions to the historic literature of the subject cannot fail to be favorable to the increasing cultivation of the science, both in its theoretical and practical aspects.

A feature of the occasion of peculiar interest was the collection of various memorials of Dr. Priestley, conveniently arranged in a large room for general inspection. There were many vestiges of the apparatus he used in his chemical investigations, and of his microscopical and electrical instruments. There were also copies of his numerous works in various languages, and several portraits and engravings, illustrative of the events and circumstances of his life. These relics were of great interest, and were examined with much curiosity by those who had made the pilgrimage to the scene of his closing labors.

The house which Dr. Priestley built, and in which he died, was also visited, and found to be in a good state of preservation. It is an ample wooden structure, plain, but thoroughly finished. Attached to it on one side was his laboratory—a large apartment, with a chimney in one corner for the escape of chemical exhalations. The situation of the dwelling was once fine, the spacious grounds sloping down to the Susquehanna, and being covered with trees. But there is now a canal in front, and a railroad at the back-door, which render it ineligible for a residence; and the pilgrims were informed, by a conspicuous sign, that it was "for sale." It seems there has been a rumor that the house was haunted, but this was strenuously denied on the part of those who were interested in disposing of it.

The descendants of Dr. Priestley, to the sixth generation, are to be found in Northumberland, and, as we might naturally expect, the family has been prominent in the history of the town. Dr. Joseph Priestley, a leading physician of the place, and his brother, Marks B. Priestley, great-grandsons of the old doctor, are prominent citizens, and their doors were thrown open with a cordial hospitality to the strangers who had come together to honor their illustrious ancestor. Other citizens, moreover, gave a kindly and generous welcome to the visitors, and did all in their power to make the occasion as pleasant as it must ever be memorable to all who participated in it.

RECENT PROGRESS IN THE HIGHER EDUCATION.

It cannot be otherwise than gratifying to all the friends of improvement in the higher culture of the country to have noted the recent indications of a rapidly deepening popular interest in the subject. That an intelligent public such as ours should entertain a profound concern for its common schools, and strive incessantly for their amendment, is nothing more than might be expected; but, that vast multitudes of people should be stirred with intense solicitude about the result of the latest reform in collegiate education is no less remarkable than encouraging. It has been reproachfully said that people brought up under a popular form of government, with equal rights, claims, and privileges, will become so steeped in democratic sentiment as to have little care for that high and thorough training which but a small and select portion of the community can attain, and for which it is the main office of universities to provide. But we have now before us indubitable proof that crowds of people of all sorts and grades may be agitated to the utmost depths and carried away in enthusiasm over the workings of our collegiate system. At the late competitive examination, held at Saratoga, to decide upon the relative attainment in a new branch of scholarship, nine of the leading colleges of the country entered the lists, and the concourse of people that gathered to witness the exercises and note the result was something altogether unprecedented among educational exhibitions on this side of the Atlantic. It can no longer be said that learning and its devotees are unappreciated by our people. They came from all parts of the country through the sweltering heat, were thickly stowed away in suffocating bedrooms, relished the stale mutton and wilted cucumbers furnished by the landlords, and trailed day after day through miles of grime and smudge to reach the place of inter-collegiate trial, and went wild with tumultuous excitement when one group of students exhibited greater proficiency than the rest. It was a great event for the higher education of this land, and will no doubt result in many new accessions to the college classes, and in raising still higher the standard of attainment in the new direction of study.

LITERARY NOTICES.

Logic, Inductive and Deductive. By Alexander Bain, LL.D., Professor of Logic in the University of Aberdeen. New and Revised Edition. 731 pages. Price, $2.00. D. Appleton & Co.

From Aristotle, the father of the science, to the present day, logic has been one of the leading elements of a liberal education. During the middle ages it was understood and practised as the art of reasoning; with the rise of modern science, it has been systematically extended so as to embrace the laws or principles to which the mind conforms in the search for truth. Dependent upon the larger science of mental philosophy or psychology, it has been constantly affected by the progress that has taken place in the knowledge of mind. The most influential modern work upon this subject is that of Mr. Mill, who was incited to undertake it by the perusal of Dr. Whewell's "History of the Inductive Sciences." His Logic was undoubtedly Mill's great work, and will occupy a prominent place in the history of the development of the science; but it aimed to be a constructive and epoch-making treatise, and was designed for the use of scholars rather than for general students.

Mr. Bain was the life-long and intimate friend of Mr. Mill, and was intrusted by the latter with the supervision of the proofs of the first edition of his work on logic for the press. He is, besides, one of the leading psychologists of the age, and author of a system of mental philosophy, which stands high as an original contribution to the advancement of the subject. He has been Professor of Logic in the University of Aberdeen for many years, and was thoroughly qualified to prepare a valuable book upon the subject. But, whereas Mill addressed himself to philosophers, and occupied himself with abstruse and original inquiries, Mr. Bain has taken for his task to treat the subject in a more popular manner, adapted to all classes of students. His volume may be regarded as, in fact, a popular treatise from the most modern point of view; and so well has he succeeded with this feature of the work, that persons entirely unfamiliar with the subject may read it with interest and profit.

And yet nothing would be more unjust to Prof. Bain than the idea that his work is in any sense a compilation. It is, on the contrary, a treatise of marked originality, and has been developed entirely from the author's point of view as an independent student. One of the most instructive and interesting parts of the volume is book fifth, treating of the "Logic of the Sciences," or, what may be called, logic in its concrete and practical applications. "The Logic of Mathematics," "The Logic of Physics," of Chemistry, of Biology, of Psychology, of Politics, of Medicine, and what the author calls "The Logic of Practice," are considered in separate chapters, and, in connection with the "Classification of the Sciences," they form a most valuable statement of the fundamental ideas and the peculiar conditions of reasoning in all these important branches of knowledge. Although the work is comprehensive and a perfect treasury of information upon the subject, yet Dr. Bain points out in the preface how it may be used as an elementary book, while its extremely low price is favorable to its general introduction into schools.

Ancient Faiths embodied in Ancient Names; or, an Attempt to trace the Religious Belief, Sacred Rites, and Holy Emblems of Certain Nations, by an Interpretation of the Names given to Children by Priestly Authority, or assumed by Prophets, Kings, and Hierarchs. By Thomas Inman, M. D. (London). 2 vols. 8vo, pages 792 and 1028. Price, $27.00. Second Edition. New York: Asa K. Butts & Co., 36 Dey Street, 1874.

This is, undoubtedly, a work of vast research, and implying, in the author, an intimate acquaintance with the languages and literatures of antiquity. We have, here, an immense amount of curious knowledge with regard to the sacred rites of ancient religions. The emblems, symbols, or images, which have served as representatives of Deity, and which have received worship from man, are shown to be much the same the world over. The author very elaborately develops the precise meaning of the principal emblems used to represent the Supreme Being, and one of the most interesting features of his book is the learning with which these are traced through the Assyrian, Hebrew, Syrian, and other religions, and even the Christian religion itself, in some of its forms. The central idea of the work, if it has any central idea, is not indicated by the title. Judging from that, the reader would expect to find a list of names of persons analyzed, and, from the elements of these names, the religious beliefs and practices of those who gave or wore them inferred: that is to say, the work would be mainly philological. This, however, is not the case; the work is rather historical. The subjects are treated in alphabetical order, and this, by-the-way, is the only sign of order we find in the work: the same topics are treated over and over again, even unto weariness and disgust. Special prominence is given to the discussion of the relations of sex to the problem of religious emblems, a question which has latterly much engaged the attention of archæologists. From the following very brief list of subjects, our readers will, perhaps, be able to see the scope of the work: Anthropomorphism, Ark, Canon of Scripture, Chrisna, Cross, Demon, Hell, JAH, Infidelity, Inspiration, Mary, Miracles, Oracles, Phallus, Prayer, Prophecy, Religion, Sabbath, Sacti, Sun-worship, Theology, Trinity, Urim and Thummim. Though many extraneous matters are brought into this work, which, it would seem, ought to have been discussed elsewhere, the reader will hardly be disposed to complain, for all that the author writes is worthy of consideration, even if out of place. The text is fully and elegantly illustrated with woodcuts and plates.

Health and Education. By the Rev. Charles Kingsley, F. L. S., F. G. S., Canon of Westminster. New York: D. Appleton & Co., 549 & 551 Broadway. Pages 411. Price, $2.00.

This is a unique volume from the vigorous and brilliant pen of the versatile Canon of Westminster, novelist, essayist, naturalist, professor of history, and preacher, and so strong in each as to have won a commanding place in the literature of the time. Mr. Kingsley has here given us the result of his long observations and reflections on the theory, philosophy, and practical conduct of life. His work is popular in the highest sense; that is, it is not only designed for general influence, but it is done in its author's best style of literary art, and is vivid, quaint, pungent, and impressive. It is well known that Canon Kingsley is one of the masters of the English language, and it is fortunate when he brings his unusual powers of presentation to bear upon familiar and important subjects of daily life. For the difficulty with people generally is, not that they are ignorant, or have not had truth enough explained to them, but that it is so vaguely conceived and so feebly held that it does not take hold of the feelings and coerce the conduct. For this reason, much of the tame didactic statement of current science is to a great degree powerless for good. It is here that the forcible, pointed, and picturesque writer is of invaluable service, and it is here that Canon Kingsley excels. The contents of the volume are varied and suggestive, and it abounds in passages of pointed common-sense, like the following fresh plea for the practical study of botany by girls, as grounds of important mental discipline:

"Mothers complain to me that girls are apt to be—not intentionally untruthful—but exaggerative, prejudiced, incorrect, in repeating a conversation or describing an event; and that from this fault arise, as is to be expected, misunderstandings, quarrels, rumors, slanders, scandals, and what not.

"Now, for this waste of words there is but one cure: and if I be told that it is a natural fault of women; that they cannot take the calm, judicial view of matters which men boast, and often boast most wrongly, that they can take; that under the influence of hope, fear, delicate antipathy, honest moral indignation, they will let their eyes and ears be governed by their feelings; and see and hear only what they wish to see and hear: I answer, that it is not for me as a man to start such a theory; but that, if it be true, it is an additional argument for some education which will correct this supposed natural defect. And I say deliberately that there is but one sort of education which will correct it; one which will teach young women to observe facts accurately, judge them calmly, and describe them carefully, without adding or distorting: and that is, some training in natural science.

"I beg you not to be startled: but if you are, then test the truth of my theory by playing to-night at the game called 'Russian Scandal;' in which a story, repeated in secret by one player to the other, comes out at the end of the game, owing to the inaccurate and—forgive me if I say it—uneducated brains through which it has passed, utterly unlike its original; not only ludicrously maimed and distorted, but often with the most fantastic additions of events, details, names, dates, places, which each player will aver that he received from the player before him. I am afraid that too much of the average gossip of every city, town, and village is little more than a game of 'Russian Scandal;' with this difference, that, while one is but a game, the other is but too mischievous earnest.

"But now, if among your party there should be an average lawyer, medical man, or man of science, you will find that he, and perhaps he alone, will be able to retail accurately the story which had been told him. And why? Simply because his mind has been trained to deal with facts; to ascertain exactly what he does see or hear, and to imprint its leading features strongly and clearly on his memory.

"Now, you certainly cannot make young ladies barristers or attorneys; nor employ their brains in getting up cases, civil or criminal; and as for chemistry, they and their parents may have a reasonable antipathy to smells, blackened fingers, and occasional explosions and poisonings. But you may make them something of botanists, zoologists, geologists.

"I could say much on this point: allow me at least to say this: I verily believe that any young lady who would employ some of her leisure time in collecting wild-flowers, carefully examining them, verifying them, and arranging them; or who would in her summer trip to the sea-coast do the same by the common objects of the shore, instead of wasting her holiday, as one sees hundreds doing, in lounging on benches on the esplanade, reading worthless novels, and criticising dresses—that such a young lady, I say, would not only open her own mind to a world of wonder, beauty, and wisdom, which, if it did not make her a more reverent and pious soul, she cannot be the woman which I take for granted she is; but would save herself from the habit—I had almost said the necessity—of gossip: because she would have things to think of and not merely persons; facts instead of fancies; while she would acquire something of accuracy, of patience, of methodical observation and judgment, which would stand her in good stead in the events of daily life, and increase her power of bridling her tongue and her imagination. 'God is in heaven, and thou upon earth; therefore let thy words be few;' is the lesson which those are learning all day long who study the works of God with reverent accuracy, lest by misrepresenting them they should be tempted to say that God has done that which he has not; and in that wholesome discipline I long that women as well as men should share."

In his lecture on the Tree of Knowledge, Mr. Kingsley has the following observations on the causes of intemperance:

"It is said by some that drunkenness is on the increase in this island. I have no trusty proof of it: but I can believe it possible; for every cause of drunkenness seems on the increase. Overwork of body and mind; circumstances which depress health; temptation to drink, and drink again, at every corner of the streets; and finally, money, and ever more money, in the hands of uneducated people, who have not the desire, and too often not the means, of spending it in any save the lowest pleasures. These, it seems to me, are the true causes of drunkenness, increasing or not. And if we wish to become a more temperate nation, we must lessen them, if we cannot eradicate them.

"First, overwork. We all live too fast, and work too hard. 'All things are full of labor, man cannot utter it.' In the heavy struggle for existence which goes on all around us, each man is tasked more and more—if he be really worth buying and using—to the utmost of his powers all day long. The weak have to compete on equal terms with the strong; and crave, in consequence, for artificial strength. How we shall stop that I know not, while every man is 'making haste to be rich, and piercing himself through with many sorrows, and falling into foolish and hurtful lusts, which drown men in destruction and perdition.'

"But it seems to me also, that in such a state of society, when—as it was once well put—'every one has stopped running about like rats:'—that those who work hard, whether with muscle or with brain, would not be surrounded, as now, with every circumstance which tempts toward drink; by every circumstance which depresses the vital energies, and leaves them an easy prey to pestilence itself; by bad light, bad air, bad food, bad water, bad smells, bad occupations, which weaken the muscles, cramp the chest, disorder the digestion. Let any rational man, fresh from the country—in which I presume God, having made it, meant all men, more or less, to live—go through the back streets of any city, or through whole districts of the 'black countries' of England; and then ask himself—Is it the will of God that his human children should live and toil in such dens, such deserts, such dark places of the earth? Let him ask himself—Can they live and toil there without contracting a probably diseased habit of body; without contracting a certainly dull, weary, sordid habit of mind, which craves for any pleasure, however brutal, to escape from its own stupidity and emptiness? When I run through, by rail, certain parts of the iron-producing country—streets of furnaces, collieries, slag-heaps, mud, slop, brick house-rows, smoke, dirt—and that is all; and when I am told, whether truly or falsely, that the main thing which the well-paid and well-fed men of those abominable wastes care for is—good fighting-dogs: I can only answer, that I am not surprised.

"I say—as I have said elsewhere, and shall do my best to say again—that the craving for drink and narcotics, especially that engendered in our great cities, is not a disease, but a symptom of disease; of a far deeper disease than any which drunkenness can produce; namely, of the growing degeneracy of a population striving in vain by stimulants and narcotics to fight against those slow poisons with which our greedy barbarism, miscalled civilization, has surrounded them from the cradle to the grave. I may be answered that the old German, Angle, Dane, drank heavily. I know it: but why did they drink, save that for the same reason that the fenman drank, and his wife took opium, at least till the fens were drained? why but to keep off the depressing effects of the malaria of swamps and new clearings, which told on them—who always settled on the lowest grounds—in the shape of fever and ague? Here it may be answered again, that stimulants have been, during the memory of man, the destruction of the Red Indian race in America. I reply boldly, that I do not believe it. There is evidence enough in Jacques Cartier's 'Voyages to the Rivers of Canada;' and evidence more than enough in Strachey's 'Travaile in Virginia'—to quote only two authorities out of many—to prove that the Red Indians, when the white man first met with them, were, in North and South alike, a diseased, decaying, and, as all their traditions confess, decreasing race. Such a race would naturally crave for 'the water of life,' the 'usquebaugh,' or whiskey, as we have contracted the old name now. But I should have thought that the white man, by introducing among these poor creatures iron, fire-arms, blankets, and, above all, horses wherewith to follow the buffalo-herds which they could never follow on foot, must have done ten times more toward keeping them alive, than he has done toward destroying them by giving them the chance of a week's drunkenness twice a year, when they came in to his forts to sell the skins which, without his gifts, they would never have got.

"Such a race would, of course, if wanting vitality, crave for stimulants. But if the stimulants, and not the original want of vitality, combined with morals utterly detestable, and worthy only of the gallows—and here I know what I say, and dare not tell what I know, from eye-witnesses—have been the cause of the Red Indians' extinction: then how is it, let me ask, that the Irishman and the Scotsman have, often to their great harm, been drinking as much whiskey—and usually very bad whiskey—not merely twice a year, but as often as they could get it, during the whole 'iron age;' and, for aught any one can tell, during the 'bronze age,' and the 'stone age' before that: and yet are still the most healthy, able, valiant, and prolific races in Europe? Had they drunk less whiskey they would, doubtless, have been more healthy, able, valiant, and perhaps even more prolific, than they are now. They show no sign, however, as yet, of going the way of the Red Indian.

"But if the craving for stimulants and narcotics is a token of deficient vitality; then the deadliest foe of that craving, and all its miserable results, is surely the Sanitary Reformer; the man who preaches, and—as far as ignorance and vested interests will allow him—procures, for the masses, pure air, pure sunlight, pure water, pure dwelling-houses, pure food. Not merely every fresh drinking-fountain: but every fresh public bath and wash-house, every fresh open space, every fresh growing tree, every fresh open window, every fresh flower in that window—each of these is so much, as the old Persians would have said, conquered for Ormuzd, the god of light and life, out of the dominion of Ahriman, the king of darkness and of death; so much taken from the causes of drunkenness and disease, and added to the causes of sobriety and health.

"Meanwhile one thing is clear: that if this present barbarism and anarchy of covetousness, miscalled modern civilization, were tamed and drilled into something more like the kingdom of God on earth: then we should not see the reckless and needless multiplication of liquor-shops, which disgraces this country now. . . .

"I said just now that a probable cause of increasing drunkenness was the increasing material prosperity of thousands who knew no recreation beyond low animal pleasure. If I am right—and I believe that I am right—I must urge on those who wish drunkenness to decrease, the necessity of providing more, and more refined, recreation for the people.

"Men drink, and women too, remember, not merely to supply exhaustion; not merely to drive away care; but often simply to drive away dullness. They have nothing to do save to think over what they have done in the day, or what they expect to do tomorrow; and they escape from that dreary round of business thought, in liquor or narcotics. There are still those, by no means of the hand-working class, but absorbed all day by business, who drink heavily at night in their own comfortable homes, simply to recreate their overburdened minds. Such cases, doubtless, are far less common than they were fifty years ago: but why? Is not the decrease of drinking among the richer classes certainly due to the increased refinement and variety of their tastes and occupations? In cultivating the æsthetic side of man's nature; in engaging him with the beautiful, the pure, the wonderful, the truly natural; with painting, poetry, music, horticulture, physical science—in all this lies recreation, in the true and literal sense of that word, namely, the recreating and mending of the exhausted mind and feelings, such as no rational man will now neglect, either for himself, his children, or his workpeople."

Catalogue of the South Missouri State Normal School, Warrensburg, James Johonnot, Principal. Jefferson City: Regan & Carter.

Of all the forms of ephemeral literature, school catalogues are generally the most volatile, fleeting, and thoroughly worthless. The luxurious typography is, no doubt, pleasant to the pupils whose names are in the list, and, indicating the prosperity of the establishment, is a highly-dignified method of advertising. The deep philosophy of education that is propounded, and the high-sounding promises of what is to be done next year, dressed in imposing rhetoric, are agreeable to read, but unsafe to trust, as they usually have a very loose relation with the facts.

The catalogue before us, however, is of quite exceptional character, and has interested us not a little. It is the result of a serious and earnest effort to carry out advanced ideas, and to place popular education more completely upon the basis of scientific principles than has hitherto been deemed practicable. In his eight pages of preliminary explanation of the course of study, Prof. Johonnot has given us a brief and excellent exposition of the underlying ideas of the new education, and has given ample and cogent reasons why the sciences should have a leading place in our improved systems of mental cultivation. But no amount of theorizing can be sufficient here. What we want is an actual curriculum, and the practical results of its working. Scientific education cannot be constructed, it must grow; but that growth can only come from trial and experience, and, what we want, therefore, is judicious educational experimenters to develop the new culture and show what it is capable of. They have entered boldly upon this path at the Warrensburg Normal School, and with something like an adequate appreciation of the just claims of scientific studies. While it is regarded by many educators as a great step of reform to recognize science at all, and to concede one, two, or three hours a week to some branches of it, Prof. Johonnot makes it the prominent and fundamental thing in the establishment over which he presides. Of the several lines of study, science occupies the first place, and is a regular daily exercise in every term. "In each science a strictly objective presentation is first made, by which the pupil observes the objects and facts upon which the science is founded, and is led to make general classifications. Farther along in the course, each science is treated again upon a higher plane, leading to more minute investigations and to broader generalizations; and in several instances the subject recurs three times before it is finally dismissed." We may add that the scientific course is broad and comprehensive, and one of the features of the plan of teaching is the explanation of new discoveries and important results, as fast as they occur in the scientific world.

PUBLICATIONS RECEIVED.

Nomenclature of Diseases (Woodworth). Washington: Government Printing-Office. Pp. 232.

Exposures in Fire Insurance (Ross). New York: Appletons. Pp. 59.

National Educational Association. 1873. Pp. 272.

Physiology of the Circulation (Pettigrew). Macmillan. Pp. 337. Price, $4.00.

Catalogue of Wild Plants in New Jersey (Willis). New York: Schermerhorn. Pp. 92. Price, $1.00.

Elmwood Cemetery, Memphis. Pp. 222.

United States Mining Industry (Raymond). New York: Ford & Co. Pp. 555. Price, $4.50.

The Stevens Battery. Pp. 30.

Morgan Expeditions, 1870–'71. Pp. 60.

Reception of Dr. Gould at Boston. Pp. 32.

Report of the Curators of Missouri University (1874). Pp. 185.

Kindergarten Messenger (Monthly). Pp. 24.

Bulletin of Cornell University (Science). Vol. I. Nos. 1 and 2. Pp. 63.

The Rapid Writer (Monthly). Andover, Mass. Pp. 16.

Bench and Bar Review (Quarterly). Baltimore: A. Schaumburg. Pp. 200. Per annum, $5.00.

Kentucky State Medical Association. 1874. Pp. 262.

Experiments, showing Character and Position of Neutral Axes (Nickerson, C. E.). Pp. 26.

"Do Snakes swallow their Young?" (Goode). Pp. 12.

The Analyst, Monthly Journal of Pure and Applied Mathematics. Des Moines, Iowa. Pp. 20.

Mechanical Properties of Materials of Construction (Thurston). Pp. 28.

Assaying by the Spectroscope (Du Bois). Pp. 12.

The Mystery of Life (Cox). Pp. 32.

The Plagopterinæ and the Ichthyology of Utah (Cope). Pp. 14.

Transmission of Diseases (Hamlin). Pp. 9.

Papers chiefly Anatomical (Wilder). Pp. 94.

Transformations of the House-Fly (Packard). Pp. 14.

Geographical Variation of North American Birds (Allen). Pp. 10.

Mammals of Kansas, etc. (Allen). Pp. 23.

Statistical Atlas of the United States. Part III. Vital Statistics.

Darwinism and Language (Whitney). Pp. 30.

MISCELLANY.

Coggia's Comet.—The comet which lately made such a grand display in our northern heavens was discovered by Coggia, at Marseilles, on April 17th. When first seen, the nucleus and coma together had a diameter of 100,000 miles, the comet being then 133,000,000 miles from the earth, and 153,000,000 from the sun. It travels round the sun in the same direction as the planets, but in an orbit the plane of which is very much inclined. Of all the planetary orbits, excepting those of the asteroids, that of Mercury is most oblique, having a slant of seven degrees; but the inclination of the orbit of Coggia's Comet is nearly ten times as great, being set down at 66°. Its perihelion passage, or nearest approach to the sun, occurred on July 8th, when it came within 62,000,000 miles of that orb, and it was then moving at the rate of 160,000 miles an hour. It continued to approach the earth until July 20th, coming, on that date, within 26,000,000 miles of us, when it appeared at its brightest, or, according to Prof. Parkhurst, 140 times more brilliant than when first discovered. Of its tail, the same authority says: "On June 25th the observed length of the tail was computed as 3,000,000 miles; on July 1st, 5,000,000 miles; on July 13th, 12,000,000 miles—an increase, after the first of that month, of one-twelfth per day. The tail continued, from its first appearance till the head of the comet ceased to be visible, to point from the latter directly toward the stars Beta and Gamma of the Lesser Bear. Afterward it moved slowly to the westward, so that it covered the dipper of the Greater Bear. The speed of the particles leaving the head to form the tail was estimated as over 3,000,000 miles per day. This brings the particles leaving the comet on July 4th to a distance from its head on July 24th of about 26,000,000 miles, corresponding at the latter date with the distance of the head of the comet from the earth. But, though the tail thus sweeps over sufficient space to cover the interval between the nucleus and the earth, the direction of the tail is such that it fails to reach us; its central line being distant about 4,000,000 miles, and the edge of the tail about 1,500,000 miles, from the earth."

Concerning the theory which accounts for the formation of comets' tails by a repulsive action of the sun on the matter of the nucleus, Prof. Parkhurst also writes, in the *Tribune* of July 23d: "The existence of a repelling force was suggested by the fact that a comet's tail, pointing eastward when the comet is east of the sun, points northward and westward as the comet itself moves around to the north and west of the sun. Yet, as there is no coherence in the tail, it is evident that no repelling force from the sun, when it is to the east of the sun, can have any tendency to bring it around to the west of the sun. The fact is, that the tail which is to be seen to the west of the sun is composed of entirely different matter from that which was seen to the east. The former matter has been repelled so far from the sun, and has been so expanded, that it has become invisible; and new matter has been repelled from the nucleus, forming a new tail upon the western side. The law of repulsion will not only account for this, but for the formation of a new tail at the rate of 30,000,000 miles per day, as recorded in the case of the comets of 1680 and 1843. The magnitude of the comet's tail in those instances was stupendous; but its velocity was no less astounding. It commenced to move at the rate of 30,000,000 miles per day; but, unlike the motion of the comet itself, the motion is accelerated so long as the repelling force continues to operate. There is no retarding force, as in the motion of a receding comet. Whatever velocity has once been reached is retained, and the particles are constantly receiving an accelerating force from the time they leave the head of the comet, although the amount of the accelerating force which they receive will gradually diminish as the distance from the sun increases. There is no known instance of a comet coming into our system with a velocity approaching this; and, as the tail of a comet is chiefly formed after it has passed its perihelion, when each successive addition to the tail is impelled with less velocity than that which started before it, there seems to be no alternative to the theory that the matter forming a comet's tail is so thoroughly diffused in space that it can never be reunited."

Astronomers appear to be agreed that Coggia's Comet is an entire stranger to us, if not to these regions of space. It was at first surmised that it might be the one seen by the French missionaries in China in 1737, thus making its period of revolution 137 years. But the opinion of Prof. Hind, as lately expressed in *Nature*, is that, notwithstanding similarity of orbit, the two are not identical. The orbit of this latest comer has not been definitely determined, but is pronounced either a parabola or hyperbola. As the comet will be visible in the Southern Hemisphere until the end of September, more on this interesting point will probably be learned before its final disappearance.

Brain Development in the Mammalia.—According to the researches of Prof. Marsh, the larger mammals of the Tertiary period, as compared with their existing representatives, were sadly deficient in brains. Their later remains, however, afford evidence of steady improvement in this particular. The mammals of the Eocene all had small brains, being little better provided in this respect than the higher reptiles. The type genus of the largest of the Eocene mammalia, *Dinoceras*, nearly equaled the elephant in bulk, but had a brain only about one-eighth the size of that in existing rhinoceroses. The smallness of the cavity in the other genera of this order was equally remarkable. The Brontotherium of the American Miocene (a later division of the Tertiary), while equaling the dinoceras in size, had a decidedly larger brain-cavity; and, in the still later strata of the Pliocene, a species of mastodon was found which likewise exhibited increase of brain-dimensions, the cavity approaching but not equaling that of existing proboscidians." The Tapiroid ungulates of the Eocene had small brain-cavities, much smaller than their allies the Miocene *Rhinocerotidæ*. The Pliocene representatives of the latter group had well-developed brains, but proportionally smaller than living species. A similar progression in brain-capacity seems to be well marked in the equine mammals, especially from the Eocene *Orohippus*, through *Miohippus* and *Anchitherium* of the Miocene, *Pliohippus* and *Hipparion* of the Pliocene, to the recent *Equus*. In other groups of mammals, likewise, so far as observed, the size of the brain shows a corresponding increase in the successive subdivisions of the Tertiary. These facts have a very important bearing on the evolution of mammals, and open an interesting field for further investigation."

The Peabody Museum of Natural History.—We learn from the *College Courant* that the Peabody Museum of Natural History, connected with Yale College, is to be commenced at once. The building, when complete, will be 350 feet in length. At present, only one wing is to be built, cost-ing $160,000, with a ground-plan of 115 feet by 100. It will be of brick, with cut-stone trimmings, and strictly fire-proof; of three stories, with high basement, making, virtually, four stories. This basement will be largely devoted to the exhibition of fossil footprints. The first story will be devoted to a lecture-room and a mineralogical cabinet; the second to geology, with the fossil vertebrates from the Rocky Mountains; the third to zoology, and the attic to archæology and ethnology. The funds for the erection and maintenance of this institution were furnished, in 1866, by the late George Peabody, who, by deed of gift dated October 22d of that year, gave $150,000 to Profs. J. D. Dana, O. C. Marsh, B. Silliman, G. J. Brush, and three others, in trust "to found and maintain a Museum of Natural History, especially of the departments of zoology, geology, and mineralogy, in connection with Yale College." The present curators of the several departments of the Museum are Prof. Brush, of the mineralogical, Prof. Marsh, of the geological, and Prof. A. E. Verrill, of the zoological department.

The Movement of Storms.—The *American Journal of Science* for July contains Part I. of an able paper, by Prof. Loomis, entitled "Results derived from an Examination of the United States Weather Maps for 1872 and 1873," read before the National Academy of Sciences in April last. The weather-maps which furnished the data for his examination exhibit storm-paths for 314 days. These he has carefully tabulated and classified. The course and velocity of the storms for each month are given, showing that the average velocity in forward movement was 26.6 miles per hour, that the greatest average velocity in any month was in February, it being 31 miles per hour; the lowest was in August, when the rate was 17.7 miles an hour. It also appears that their forward movement is greater in winter than in summer. But some atoms move with exceptional velocity. Thus, in May 15, 1873, a storm-centre advanced 1,200 miles in twenty-four hours, while, in other cases, there was no forward movement, and the storm-centre remained stationary for twenty-four hours. The average direction of the storm-paths for two years was 8° north of east; in summer, nearly due east; in winter, more northward; but most northward in fall and spring. In October the direction was 21° north of east. Instances occurred, however, in which storms moved north-northwest; and, on the 6th of April, 1873, a storm in the Mississippi Valley moved in every direction in a little more than twenty-four hours.

Prof. Loomis carefully studied the causes which appear to influence the velocity and direction of storms. Of these, rainfall is important. It is found that the area of rainfall extends farther on the eastern than it does on the western side of a storm-centre; so that the rain-area is a long oval, the longer diameter of which is in or nearly in the direction in which the storm is moving. This is true of most of the storms which traverse the United States. This rain-area extends to an unusual distance on the eastern side of a storm when it is advancing—the average extent being about 500 miles.

By the condensation of vapor eastward of the storm, it, in a measure, makes its own way. Thus the barometer continually falls in advance of it, announcing its approach, but rises as the storm-centre is past. The conditions by which a storm is sustained, and which are present before or in front of it, cease to exist in its wake. Instances occur, however, in which increased velocity and condensation in the western quadrant of a storm set back the storm's centre, and give it, for a time, a retrograde motion. The wind on the western quarter of a storm usually blows with greater velocity by about 22 per cent. than it does on its eastern quadrant, and this is a means by which the forward motion is retarded; and it is found that, when the wind's velocity in the western quadrant is 44 per cent. greater than in the eastern, the storm's forward motion is seven miles an hour less than its average rate of progress.

The atmosphere in the storm circuit moves inward, but also upward, to the central region of the storm, which is supposed to be from one to two miles above the earth's surface. At this elevation atmospheric movements are greatly increased in velocity. Thus, at the summit of Mount Washington, the velocity was 29 miles an hour, or, compared with that at the level of the sea, was as 5.5 to 1. By comparing the velocity of the wind at this elevation in the direction which the storm advances with the velocity of the storm's advance, Prof. Loomis is enabled to deduce a measure of the force of the upward movement of the centre of a storm.

Storms are divided, by Prof. Loomis, into two classes. Those of the first class traverse the continent northward of the fortieth parallel; many from the remote west reach the great lakes Superior and Huron, and show a decided preference for that region. Some of these have their origin among the Rocky Mountains, and some come from the mountains of Oregon. Those of the second class originate chiefly westward of the mouth of the Mississippi, and move nearly northeast. These comprise only about one-sixth of the whole number, but include some of the violent cyclones which traverse our coast.

NOTES.

Correction.—In the article on the "Development of Psychology," in the August number, page 417, a long passage is represented as quoted. The *quotation* is an error of the printer.

The National (British) Association for the Promotion of Social Science will assemble at Glasgow, September 30th, and will be in session till October 7th. President, the Earl of Roseberry. The presidents of departments are: Jurisprudence and Amendment of the Law, Lord Moncrieff; Repression of Crime, Frederick Hill; Education, Lords Napier and Ettrick; Health, Lyon Playfair; Economy and Trade, Sir George Campbell.

At the summer distribution of prizes at University College, London, the first and second places, in the mixed class of jurisprudence, were both held by ladies—Miss E. Orme, who, two years ago, took the prize in political economy, coming out first; while, in the mixed class of political economy, this year, a lady took the fourth certificate.

Mr. Lick's first gift to the California Academy of Sciences was a piece of land, worth $250,000. By his recent deed, he provides the means for the erection of a suitable building for the Academy, to cost about $250,000. This is not all. The institution is provided by the generosity of Mr. Lick with ample funds to purchase books, collections, etc., and to carry on the Academy on a firm basis. The sum of the gifts thus made to this one institution amounts to over one million dollars.

It is reported that the *Phylloxera vastatrix*, the worst of grape-vine pests, has made its way into Australia.

Another mountain of iron-ore has been discovered in Missouri. A shaft has been sunk on Shepherd Mountain, which has passed already through 70 feet of almost solid ore, and the quality of the deposit is improving as the shaft goes down. Shepherd Mountain is about six miles south of the famous "Iron Mountain."

A dispatch from Denver, Col., dated July 20th, states that the three topographical divisions of Prof. Hayden's Exploring Expedition had already taken the field, and Prof. Gardner's party was soon to follow. Dr. Hayden, with his selected party, will review the whole ground, viz., that part of Colorado south of the 40th parallel, and west of the Park Range. The expedition includes fifty persons.

The large and valuable collection of natural history specimens procured by D'Albertis during his recent travels in New Guinea has been purchased by the Italian Government. D'Albertis intends soon to return to New Guinea to continue his researches.

A few drops of oil of bitter almonds on a little sawdust will serve as a good preservative of insects. Place the insects with the prepared sawdust in a hermetically-sealed flask. Insects have, in this way, been sent from Ceylon to France, and, when they reached their destination, were still so flexible as to permit of their being prepared and mounted, though they had been collected months previously.

Three thousand acres of cotton have been planted in California this year, and the prospects are good for an abundant yield.

Alphonse de Candolle, the eminent botanist of Geneva, has been elected Foreign Associate of the French Academy of Sciences, as successor of the late Prof. Agassiz.

Two scientific expeditions are to set out from Archangel next summer, one to explore the traces of ancient glaciers in Russian Lapland, and the other to pursue zoological investigations on the shore of the White Sea.

Dr. Druitt, an eminent physician and high authority on the subject of wine, says: "Civilized man must drink, will drink, and ought to drink; but it should be wine."

THE FOSSIL MAN OF MENTONE.

THE

POPULAR SCIENCE MONTHLY.

OCTOBER, 1874.

THE FOSSIL MAN OF MENTONE.

By THEODORE GILL, M. D., Ph. D.

THE attention of all the readers of The Popular Science Monthly has doubtless been attracted by the notices of the discovery, by M. Rivière, at several times within the last three years, of more or less complete fossil skeletons of man, deep in the floors of caverns near the town of Mentone. This town, formerly tolerably well known as a watering-place on the Mediterranean, in Italy, but near the present French boundary, bids fair to be best known to the readers of our own day in connection with the primitive history of our race, and as the sepulchre from which have been exhumed the oldest skeletal remains of representatives of the genus *Homo*. Of the first discovered and illustrated of these skeletons, as well as still the most complete, we now present an account, accompanied by a copy of the plate attached to the special monograph, by M. Rivière,[1] descriptive of it; the present account is almost confined to a critical analysis and *résumé* of the facts embodied in the monograph, the consideration of the more recent discoveries being best deferred to a future time, when the new facts will doubtless be detailed in a succeeding part of the monograph, and this course seems to be the most advisable, as no additional facts have been discovered which will essentially modify the conclusions and arguments herein urged.

The monograph referred to was anticipated, to some extent, by publication in the "Archives des Missions Scientifiques," published by the French Ministry of Public Instruction, and is itself issued as a

[1] Découverte d'un squelette humain de l'époque paléolithique dans les cavernes des Baoussé-Rousse, dites Grottes de Menton, par Emile Rivière. Avec deux photographies, par MM. Anfossi et Radiguet. Paris: J. B. Baillière et fils. Menton: chez l'auteur. 1873. The plate herewith given is a copy of one of those accompanying M. Rivière's memoir, and was engraved especially for the new edition of Prof. Dana's "Manual of Geology," to the publishers of which, Messrs. Ivison, Blakeman & Taylor, we are indebted for the use of it. 4to, 64 pp. Two plates.

first part of a work which the author hopes to be able to complete under the patronage of his government.

Nine caverns are now known to exist about Mentone; these are noticed by our author in inverse sequence to their numbers (i. e., the last, first, and so on). In the fourth (Caverne du Cavillon, or Barma du Cavillon) the skeleton was discovered, and in it the most complete explorations have been prosecuted; the entrance was blocked up till the commencement of this century; it is about 7 metres (23 feet) wide at the entrance, nearly 19 (62 feet) deep, and 15 or 16 (say 50 feet) high. The soil is composed in great part of ashes, the remains of a former cooking-place. For more than three months M. Rivière pushed his investigations, unearthing the remains of animals, shells, and bone or stone instruments, and, at last (on the 26th of March, 1872), was rewarded by uncovering a human foot, at a depth of between 6 and 7 metres (20 feet) below the original floor of the cave. Continuing uninterruptedly and with the greatest care, for eight days, his excavations, he finally exhumed almost the entire skeleton. The skeleton was recumbent on its left side, lengthwise in the cave, near the right wall, and about seven metres from the entrance; its attitude was that of repose—that of a man whom sudden and painless death might have surprised in sleep; so says M. Rivière.

The skeleton, when studied and compared with those of recent types of mankind, exhibited (so far as we can learn from the memoir) no differences other than of such kind as can be demonstrated in any large collection of skeletons of the various existing races; the height was above the average (and it is a pity that it was not compared with one that approximated it more in size than the one used in comparison); the arms, legs and feet furnished no unusual proportions, either in ratio to the body, or their own constituents—that is, forearm to humerus, lower leg to thigh, etc.; the vertebral column and ribs were normal; the skull was equally normal, save as to the orbits, whose transverse diameter was somewhat greater, and vertical less than usual; in short, as far as we can ascertain from our author, had the skeleton been found in an ordinary graveyard, no suspicion would have been entertained of its great antiquity.

But, in the superincumbent and surrounding earth (ashes) were found flint and bone instruments, and the remains of various animals which no longer exist in Europe, or are altogether extinct: among the latter (assuming the correctness of their determination) were remains of a panther (*Felis antiqua*, Gerv.), the tichorhine rhinoceros, a marmot (*Arctomys primigenia*, Gerv.), a deer (*Cervus Corsicanus*, Gerv. ?), and a goat (*Capra primigenia*, Gerv). The tichorhine rhinoceros, as is well known, although now extinct, has been found embalmed—skin and all—in the ice of Siberia, and must have survived long after man had originated. The other mammals cited require further study before their specific claims can be regarded as fully established. As to those species formerly existing in Europe, but which still live under somewhat modified forms, and restricted to other lands, are the lion, from which the *Felis spelæa* is scarcely distinguishable; the spotted hyena, with which the *Hyæna spelæa* has been identified; and the bear of the ancient caverns, which differs (so far as has been shown) only in its larger size from the common bear of Europe, and for this reason (and this only, apparently) has it been identified with the grizzly of America; and on similar grounds only (i. e., superior size) have some remains of a stag, found in the cave of Mentone, been referred to the living wapiti, or elk (*Cervus Canadensis*) of America. With reference to these, it must be remembered that the progenitors of our living forms, both in America and Europe, were appreciably larger (as has been shown by Baird for the mammals of the Carlisle cave) than their modern descendants, and the American contemporary of the stag hunted by the Mentone man was considerably larger than its living representative, and consequently than the animal living in his own land.

So far, then, as yet appears from our knowledge of the skeleton, and the forms found in association with it, it can only be regarded as very ancient from an historical (and not a geological) point of view. Its possessor lived in the midst of a fauna most of whose representatives still live in forms no more modified than are the existing races of the genus *Homo* compared with himself.

But, on the other hand, that his antiquity is great, and that he lived under conditions quite different from those which verbal history has preserved for us, appears to be indubitable; if many of his associates still live, it is under considerably modified forms, and other species coexistent with him (such especially as the tichorhine rhinoceros) ceased to exist before man had begun to record the existence of even the stranger forms of animal life; and how that man and his fellows ministered to their needs is, to some extent, made known to us by the objects of their handiwork preserved around the remains of the dead.

These were either of bone, or deer's-horns, or of stone; the former were relatively few, and are referred to by M. Rivière as arrow-heads, pins, needles, chisels, sleeking-tools, and a *bâton* of command (*sic!*) made from the principal left metacarpal of a horse, perforated, and supposed to have been carried around the neck; the stone implements were much more numerous, and represented by scrapers or graters, pins, arrow or lance heads, disks, knife-blades, and hammers. The workmanship was quite rude. The great predominance of ruminant (deer, goat) bones suggests their favorite food: that they used fire is obvious; and the numerous long bones of animals split lengthwise (and only five out of more than ten thousand were not) plainly indicated that they used the marrow.

We may now pause, review the evidence thus briefly referred to, and inquire what gain has resulted from the discovery of the fossil man of Mentone.

On the one hand, we had the evidence, in the remains of man and his workmanship, associated with all the characteristic animal remains referred to, that man—man, thinking and capable of applying his conceptions to fabrications for his uses—was contemporary with the cave animals, the tichorhine rhinoceros, and the mammoth; and, if the evidence is perfectly authentic (and no doubt has been expressed), that he was even prone to embody his conceptions in rude pictorial art. Thus, man had for some time been generally acknowledged to have existed at least as far back as can be claimed for the man of Mentone.

On the other hand, the skeletal remains of the man of that period were altogether too fragmentary to allow of any definite opinion as to his structural characteristics. The data for such opinion have now been rendered available by M. Rivière's discovery; and, although he has not yet published positive details, the negative results afforded us indicate that the fossil man was, in all respects, a typical man, perhaps even differing less from his successors in Europe than do some other existing races. It is at least very certain that he had no decided ape-like characteristics. Even more! He was man to excess! The proportions of the fore limb to the hind, and of the median and distal portions of each to the proximal, so far from proving a condition intermediate between man and the apes, or embryonic or juvenile humanity, or even affinity to the negro, indicate that he was more unlike the apes in such respects than are some of the existing races; nor is this evidence rebutted by any characteristics of the skull, the dentition or otherwise, so far as the testimony allows us to judge.

So much wild speculation is rife, and enthusiastic anthropologists are so much carried away by a vague idea of some startling discovery that may be at any moment made, that a counter-irritant may not be misplaced; and, where so much prophecy has been indulged, a little from ourselves may be pardoned.

With the evidences of the existence of man specialized as much as he is now, at a period so early as he is known to have lived, it is scarcely too rash to assert that it is useless to expect to find any evidence of his simian origin in any bones exhumed in the later formations in Europe, and much less in America. And, in view of the negative results of the extensive paleontological explorations made in Europe, it is almost as unlikely that any such remains will ever be found, even in the anterior formations. The anxious may therefore contemplate with a happy serenity the explorations made, for every skeleton found, in its perfect, man-like features, will not only disprove the existence of the dreaded intermediate link, but will add to the value of the negative evidence against the existence of such a link—that is, in Europe or America. And, on theoretical considerations, this is what might be expected.

But it would be altogether too rash to predict that, because no such evidence will, in all probability, be afforded by Europe or America, the evidence of the intermediate link will never be furnished. Let it be remembered that the present home of the anthropoid apes is almost entirely unknown in a paleontological point of view. When Africa or Asia shall have been half as well explored as Europe, or even America, it may then be time to predict that such evidence will never be forthcoming. But it is not likely, either, that the intermediate link will be of very recent origin; it may be found to have lived in the same epoch as did the Oreodonts and Titanotheres of America, or (exact synchronism is of no account here), as the antelopes and Helladotheres which ranged in miocene days the plains where now Athens stands; possibly even then the anthropoid Pithecoid had developed far into the pithecoid Anthropoid.

But, however this may be, the anthropologist who expects to find the evidences of man in a much less specialized condition than he now exhibits, in any very recent formation, in either Europe or America, must base his speculations on something else than known facts, and even in the face of zoological and paleontological evidence. Nor is it at all likely that the being who could fabricate tools and hunt with weapons the animals that were his contemporaries could have been very much less man-like than existing man. But we are now passing the border-line of induction from facts to speculation.

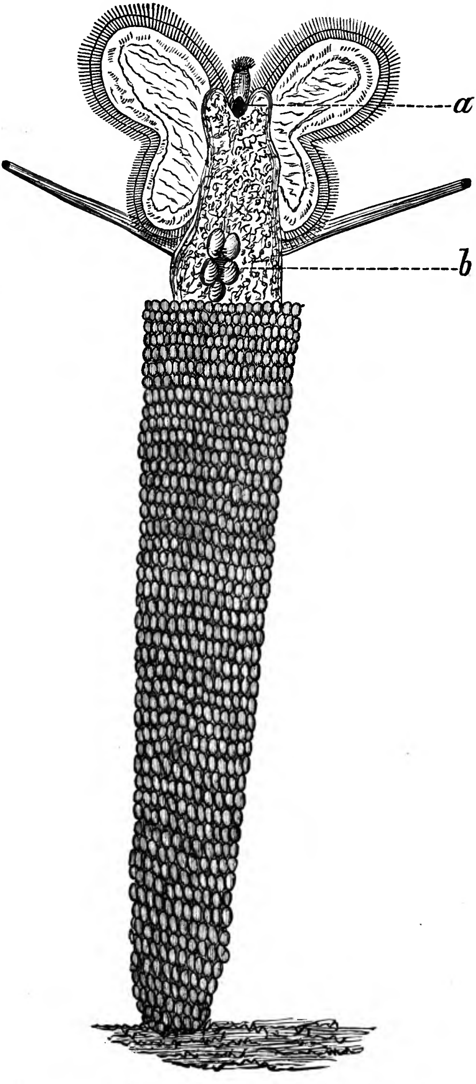
MICROSCOPIC ARCHITECTS.

By Mrs. MARY TREAT.

THERE is a world of hidden beauty of which we can form no conception without the aid of the microscope. This instrument reveals a real fairy-land, of which we may sometimes have dreamed; but our wildest fancy is more than realized by the glimpses it affords of wonderfully beautiful plants and animals. Here is a world teeming with life and animation, whose inhabitants seem to possess skill and intelligence, and have worked on, unnoticed, for ages and ages.

Some of these tiny animals are architects of no mean order, building their abodes of separate bricks or pellets, laying them in tiers, as a mason or bricklayer would build a house. One of the most beautiful of these animals is the Brickmaker (*Melicerta ringens*). Fig. 1 represents it as seen with a magnifying power of 160 diameters. It was known to Leuwenhoek nearly two hundred years ago, or about the beginning of the eighteenth century. A few years later Linnæus mentions the marvelous beauty of this tiny workman, and comments upon the regularity and beauty of the house in which it dwells. If these early observers found so much to admire, with the imperfect instruments of that day, how much more are we enabled to see clearly

Fig. 1



Melicerta Ringens.—*a*, Apparatus for moulding brick ; *b*, mouth.

the wonderful visions presented to us by the greatly improved microscopes of to-day!

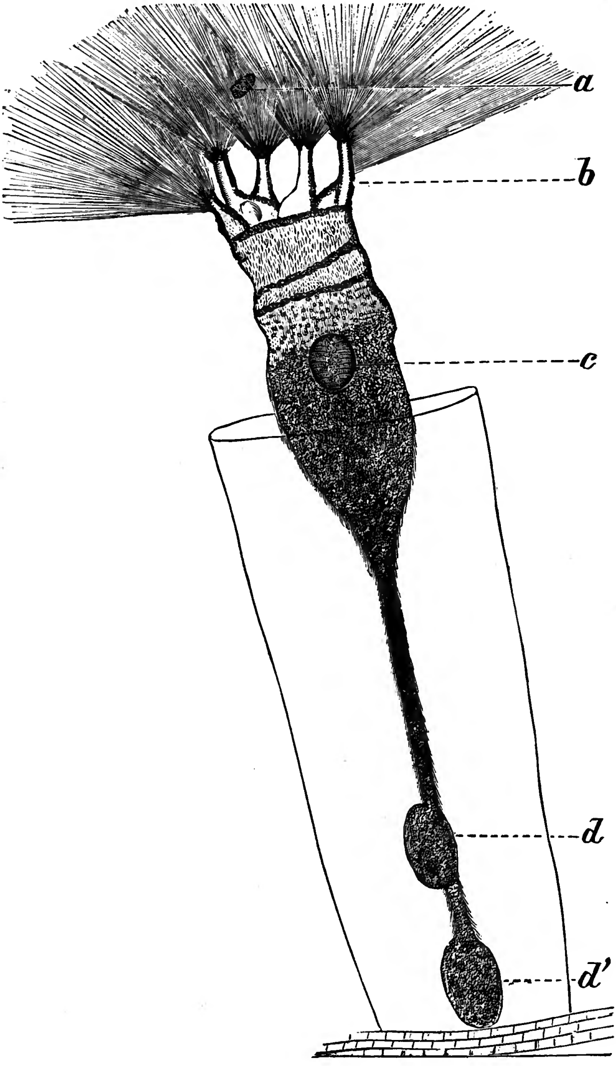
Although *Melicerta ringens* was known so long ago, yet Mr. Gosse was the first to describe the manner of its building its abode. The few who have made these microscopic creatures a study have recorded their labors in many volumes, scarcely attainable to the ordinary lover of natural history.

The animals figured and described here are as seen through a binocular microscope, with a magnifying power of 160 diameters. This power enables us to clearly define each separate brick in the tube of Melicerta, and to note the firmness and regularity of the structure. Although built of round bricks, yet it is so constructed that there are no interstices or spaces between. No bird, no other animal, not even man himself, can excel the beautiful workmanship of this tiny creature, scarcely visible to the naked eye, yet, under the microscope, assuming vast proportions. She not only builds her house, but manufactures her own brick, and lays them up one by one with no workmen to assist. The house is usually attached to some water-plant; but I have seen the young ones, upon a few occasions, anchor their dwellings to the parent-house.

When the animal is resting, or is in any way disturbed, she settles down in the lower part of the tube; but, when all is quiet and she is in good working condition, with no nursery of young ones around her, she is pretty sure to reward us with the sight of her four beautiful wheels, which she sets in rapid motion, thus forming a swift current which brings the food and the material for the brick close to her head; and she has the power of selection, for she often rejects particles brought to her mouth. The apparatus for moulding the brick is within the body. The material is brought through the action of the wheels to a small opening, where it is passed down to the apparatus, which is in rapid, whirling motion, soldering the particles together until they become, seemingly, a solid ball; now she ejects the brick from its mould, bends her head over, and securely places it on top of the structure. It takes her about three minutes to manufacture each brick.

Finding one with a tube so long that only a part of the flower-like head could appear above the battlement, I cut about one-third of the tube away, replaced it under the microscope, and watched for the reappearance of the creature. She soon came forth, and, rather hastily, rushed up beyond the decapitated story of her house until she reached her accustomed height, when she began to unfold her petal-like lobes. Now, evidently for the first time aware of something amiss, she shot back into her house much quicker than she came up. This she repeated several times before seeming to have courage to investigate; at last she set her wheels in motion, and threw herself from side to side—quite nervous-like—not seeming to relish the situation, or really

FIG. 2



FLOSCULARIA ORNATA.—*a*, Monad; *b*, lobe; *c*, mouth; *d*, egg; *d'*, egg.

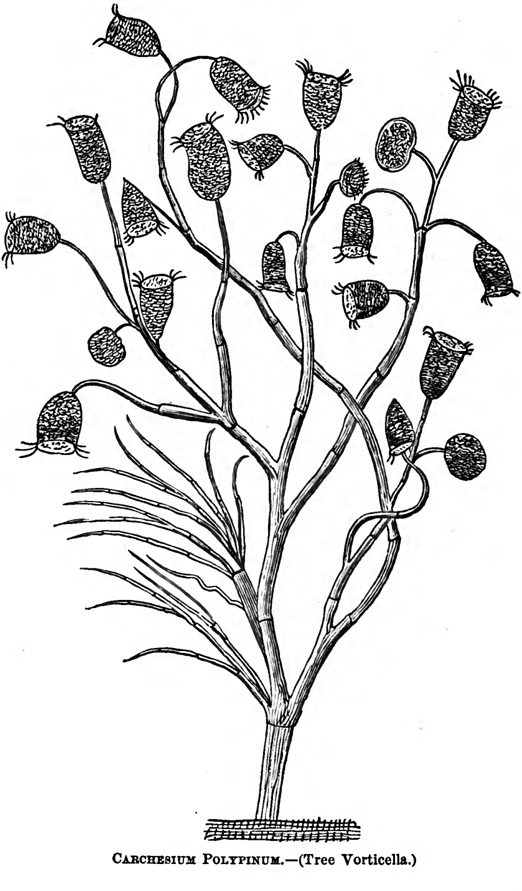
to quite comprehend what the matter was with her surroundings. It was some hours before she resumed her occupation of brickmaking, and, when one was completed, it was very amusing to watch her efforts to place it; she wasted a quantity of brick before she became aware how low down she must reach in order to rebuild, but this at last she learned, and now the work was rapidly carried forward; she had placed several new tiers around her dwelling when an accident prevented my further observation. There was no difficulty in seeing where the building recommenced, for the new brick was very much lighter colored than the old.

Fig. 2 represents the beautiful Floscule. Microscopists call it *Floscularia ornata.* Like the Brickmaker, it lives in a house, a transparent, glass-like house, which I frequently find broken, sometimes entirely demolished, as if the tenant had been in some skirmish, but they seem to get along very well without a house.

The Floscule here represented was probably blessed with an amiable disposition, and had lived a peaceable life, for she was large and well developed, and had an unbroken house to dwell in, through which we could see two large eggs near the bottom. When the eggs hatch, the little animals leave their mother's house and go floating off, living a free-and-easy sort of life; but, after a few days of this wandering, gypsy kind of existence, they seem to become impressed with the graver duties of life, and settle down and set up house-keeping on their own account.

Like the Brickmaker, the Floscule has a long footstalk, which she fastens to the leaf of some water-plant, where she remains moored during the rest of her life. She seems to be a very nervous, sensitive creature; for the slightest jar upon the table, or sometimes even a step upon the floor, or the closing of a door, will quickly send her into her glass-like house, where she settles down in a heap, looking scarcely more than an animated mass of jelly. But, if all is quiet, she soon begins to unfold, stretches out her long footstalk, which pushes up her bell-shaped body, surmounted by a mass of fine bristly filaments, which look like a dense cloud of smoke issuing from the opening at the top; and, as she gradually unfolds, we see there are five lobes to which the hair-like filaments are attached, which now begin to spread out like a fan (*see* Fig. 2). As nothing is made in vain, these filaments must in some way be of use to the animal. She cannot go in search of food, for she is firmly anchored to one spot, and has no wheels to set in motion to form a current to bring food to her: so we will carefully watch and see how she captures her prey. Here comes a little floating monad. Ah, it is caught among the bristly filaments, and flies wildly about as if bewildered; but, instead of retreating and getting away, it goes down, down, until it reaches the wide opening. This opening is surmounted by the five lobes which bear the filaments, but it is not the Floscule's mouth, the mouth is situated lower down (*see* Fig. 2), and works something like a steel-trap. Well, the little monad has got into this opening and seems to have recovered from its fright, as there is plenty of room for it to float about here; but the Floscule is now on the alert, the monad is doomed! If it tries to escape, those lobes that stand up so

Fig. 3.



Carchesium Polypinum.—(Tree Vorticella.)

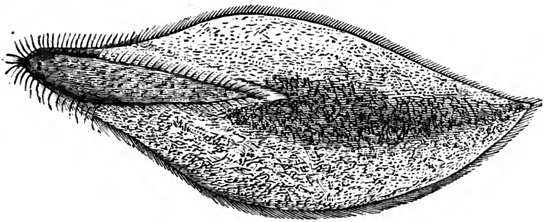
innocent-like, with their beautiful fan-shaped filaments, immediately curve over and close the opening. This movement of the Floscule usually sends the little monad close to that terrible steel-trap, when it is snapped up in a moment. Our ears are so heavy and dull, or we might fairly hear the click of her teeth, so large and voracious does she appear.

Sometimes an animal is betrayed into the opening too large for the Floscule to manage, and it is very amusing to watch its efforts to escape, and to see the Floscule try to devour it; she makes many attempts to take it into her mouth, but, at last, seeming to become discouraged, she opens wide the door and gives it permission to leave.

Fig. 3 introduces us to one of the most lovely of microscopic objects, the Tree Vorticella (*Carchesium polypinum*). Although this animal cannot be said to build a house, yet, in one sense, it is an architect, for a tree is built up in some way, and the little bell-shaped creatures hang on the ends of the branches, where they look more like flowers than animals. The stem of the tree is transparent and seems to be jointed, and the little creatures can swing the branches about, and even throw them into a spiral coil, so as to bring them close to the trunk of the tree. This gives them the appearance of being wonderfully polite: they bow and courtesy to each other as if preparing for a grand quadrille; and they are decked out in gay colors, red and green, and yellow, and the margin of the little cup is beautifully fringed with cilia, which are in rapid motion, producing a current which brings their food to them.

But one of the most curious sights I ever beheld was a Cyclops, with a Tree Vorticella growing on its back. It was a larger tree than here represented, and a different species; the branches were more straight, and much more numerous. Only think of it, an animal swimming about with a great tree of living freight on its back! But

Fig. 4.



Paramecium Caudatum (Front View).

they did not seem to have much control over the Cyclops, for he dashed about as if he did not care how many he knocked overboard! But, alas! the poor Cyclops, with his strange freight, came to grief. I undertook to transfer him to the live-box, so that our artist might have him more under control, when I brought down the cover a little too close, crushing him in the operation. This sent the vorticellas flying off their stems, and all was spoiled.

Fig. 4 represents a front view of *Paramecium caudatum.* He is not an architect, but a wandering, idle sort of fellow, often seen in company with our more staid and settled house-keepers. He gets into the oddest shapes imaginable. If he is a little cramped for room it does not seem to inconvenience him in the least, for his body is so flexible he can make it fat and dumpy, or long and slender, just as the occasion seems to require. If they have any police regulations in this fairy-world, he must be a great trial to the authorities, eluding their grasp, and bowing to them from some other quarter, entirely transformed. But, when there is nothing to interfere with his locomotion, he looks very much like a leaf, as is seen in our figure. He is covered all over with rather short, stiff hairs, or cilia, that look like porcupine-quills—perhaps they are his weapons of defense. He is not carnivorous, but lives on a vegetable diet, and is so transparent that we can always tell what he has taken for his dinner. His favorite food seems to be diatoms. These are beautiful little plants encased in a shell of various forms and colors. This curious animal sometimes manages to swallow two diatoms at once, almost as long as his body, and then he seems rather awkward and stiff, with two great logs on his stomach! But he manages, somehow, to absorb the nutritious, vegetable part of the diatom, and throws aside the beautiful transparent shell, which he has not broken nor injured at all in the operation.

INAUGURAL ADDRESS BEFORE THE BRITISH ASSOCIATION.

BY PROF. JOHN TYNDALL, D. C. L., LL. D., F. R. S., PRESIDENT.

AN impulse inherent in primeval man turned his thoughts and questionings betimes toward the sources of natural phenomena. The same impulse, inherited and intensified, is the spur of scientific action to-day. Determined by it, by a process of abstraction from experience we form physical theories which lie beyond the pale of experience, but which satisfy the desire of the mind to see every natural occurrence resting upon a cause. In forming their notions of the origin of things, our earliest historic (and doubtless, we might add, our prehistoric) ancestors pursued, as far as their intelligence permitted, the same course. They also fell back upon experience, but with this difference—that the particular experiences which furnished the weft and woof of their theories were drawn, not from the study of Nature, but from what lay much closer to them, the observation of men. Their theories accordingly took an anthropomorphic form. To supersensual beings, which, "however potent and invisible, were nothing but a species of human creatures, perhaps raised from among mankind, and retaining all human passions and appetites,"[1] were handed over the rule and governance of natural phenomena.

Tested by observation and reflection, these early notions failed in the long-run to satisfy the more penetrating intellects of our race. Far in the depths of history we find men of exceptional power differentiating themselves from the crowd, rejecting these anthropomorphic notions, and seeking to connect natural phenomena with their physical principles. But, long prior to these purer efforts of the understanding, the merchant had been abroad, and rendered the philosopher possible: commerce had been developed, wealth amassed, leisure for travel and for speculation secured, while races educated under different conditions, and therefore differently informed and endowed, had been stimulated and sharpened by mutual contact. In those regions where the commercial aristocracy of ancient Greece mingled with its Eastern neighbors, the sciences were born, being nurtured and developed by free-thinking and courageous men. The state of things to be displaced may be gathered from a passage of Euripides quoted by Hume: "There is nothing in the world; no glory, no prosperity. The gods toss all into confusion; mix every thing with its reverse, that all of us, from our ignorance and uncertainty, may pay them the more worship and reverence." Now, as science demands the radical extirpation of caprice and the absolute reliance upon law in Nature, there grew with the growth of scientific notions a desire and determination to sweep from the field of theory this mob of gods and demons, and to place natural phenomena on a basis more congruent with themselves.

The problem which had been previously approached from above was now attacked from below; theoretic effort passed from the super- to the sub-sensible. It was felt that to construct the universe in idea it was necessary to have some notion of its constituent parts—of what Lucretius subsequently called the "First Beginnings." Abstracting again from experience, the leaders of scientific speculation reached at length the pregnant doctrine of atoms and molecules, the latest developments of which were set forth with such power and clearness at the last meeting of the British Association. Thought no doubt had long hovered about this doctrine before it attained the precision and completeness which it assumed in the mind of Democritus,[2] a philosopher who may well for a moment arrest our attention. "Few great men," says Lange, in his excellent "History of Materialism," a work to the spirit and the letter of which I am equally indebted, "have been so despitefully used by history as Democritus. In the distorted images sent down to us through unscientific traditions there remains of him almost nothing but the name of the 'laughing philosopher,' while figures of immeasurably smaller significance spread themselves

[1] Hume, "Natural History of Religion."

[2] Born 460 B. C.

at full length before us." Lange speaks of Bacon's high appreciation of Democritus—for ample illustrations of which I am indebted to my excellent friend Mr. Spedding, the learned editor and biographer of Bacon. It is evident, indeed, that Bacon considered Democritus to be a man of weightier metal than either Plato or Aristotle, though their philosophy "was noised and celebrated in the schools, amid the din and pomp of professors." It was not they, but Genseric and Attila and the barbarians, who destroyed the atomic philosophy. "For, at a time when all human learning had suffered shipwreck, these planks of Aristotelian and Platonic philosophy, as being of a lighter and more inflated substance, were preserved and come down to us, while things more solid sank and almost passed into oblivion."

The principles enunciated by Democritus reveal his uncompromising antagonism to those who deduced the phenomena of Nature from the caprices of the gods. They are briefly these: 1. From nothing comes nothing. Nothing that exists can be destroyed. All changes are due to the combination and separation of molecules. 2. Nothing happens by chance. Every occurrence has its cause from which it follows by necessity. 3. The only existing things are the atoms and empty space; all else is mere opinion. 4. The atoms are infinite in number, and infinitely various in form; they strike together, and the lateral motions and whirlings which thus arise are the beginnings of worlds. 5. The varieties of all things depend upon the varieties of their atoms, in number, size, and aggregation. 6. The soul consists of free, smooth, round atoms, like those of fire. These are the most mobile of all. They interpenetrate the whole body, and in their motions the phenomena of life arise. Thus the atoms of Democritus are individually without sensation; they combine in obedience to mechanical laws; and not only organic forms, but the phenomena of sensation and thought, are also the result of their combination.

That great enigma, "the exquisite adaptation of one part of an organism to another part, and to the conditions of life," more especially the construction of the human body, Democritus made no attempt to solve. Empedocles, a man of more fiery and poetic nature, introduced the notion of love and hate among the atoms to account for their combination and separation. Noticing this gap in the doctrine of Democritus, he struck in with the penetrating thought, linked, however, with some wild speculation, that it lay in the very nature of those combinations which were suited to their ends (in other words, in harmony with their environment) to maintain themselves, while unfit combinations, having no proper habitat, must rapidly disappear. Thus more than two thousand years ago the doctrine of the "survival of the fittest," which in our day, not on the basis of vague conjecture, but of positive knowledge, has been raised to such extraordinary significance, had received at all events partial enunciation.[1]

[1] Lange, 2d edit., p. 23

Epicurus,[1] said to be the son of a poor school-master at Samos, is the next dominant figure in the history of the atomic philosophy. He mastered the writings of Democritus, heard lectures in Athens, returned to Samos, and subsequently wandered through various countries. He finally returned to Athens, where he bought a garden, and surrounded himself by pupils, in the midst of whom he lived a pure and serene life, and died a peaceful death. His philosophy was almost identical with that of Democritus; but he never quoted either friend or foe. One main object of Epicurus was to free the world from superstition and the fear of death. Death he treated with indifference. It merely robs us of sensation. As long as we are, death is not; and when death is, we are not. Life has no more evil for him who has made up his mind that it is no evil not to live. He adored the gods, but not in the ordinary fashion. The idea of divine power, properly purified, he thought an elevating one. Still he taught, "Not he is godless who rejects the gods of the crowd, but rather he who accepts them." The gods were to him eternal and immortal beings, whose blessedness excluded every thought of care or occupation of any kind. Nature pursues her course in accordance with everlasting laws, the gods never interfering. They haunt

> "The lucid interspace of world and world
> Where never creeps a cloud or moves a wind,
> Nor ever falls the least white star of snow,
> Nor ever lowest roll of thunder moans,
> Nor sound of human sorrow mounts to mar
> Their sacred everlasting calm."[2]

Lange considers the relation of Epicurus to the gods subjective; the indication probably of an ethical requirement of his own nature. We cannot read history with open eyes, or study human nature to its depths, and fail to discern such a requirement. Man never has been, and he never will be satisfied with the operations and products of the understanding alone; hence physical science cannot cover all the demands of his nature. But the history of the efforts made to satisfy these demands might be broadly described as a history of errors—the error consisting in ascribing fixity to that which is fluent, which varies as we vary, being gross when we are gross, and becoming, as our capacities widen, more abstract and sublime. On one great point the mind of Epicurus was at peace. He neither sought nor expected, here or hereafter, any personal profit from his relation to the gods. And it is assuredly a fact that loftiness and serenity of thought may be promoted by conceptions which involve no idea of profit of this kind. "Did I not believe," said a great man to me once, "that an Intelligence is at the heart of things, my life on earth would be intolerable." The utterer of these words is not, in my opinion, rendered less noble but more noble, by the fact that it was the need of ethical harmony

[1] Born 342 B. C.

[2] Tennyson's "Lucretius."

here, and not the thought of personal profit hereafter, that prompted his observation.

A century and a half after the death of Epicurus, Lucretius[1] wrote his great poem, "On the Nature of Things," in which he, a Roman, developed with extraordinary ardor the philosophy of his Greek predecessor. He wishes to win over his friend Memnius to the school of Epicurus; and although he has no rewards in a future life to offer, although his object appears to be a purely negative one, he addresses his friend with the heat of an apostle. His object, like that of his great forerunner, is the destruction of superstition; and considering that men trembled before every natural event as a direct monition from the gods, and that everlasting torture was also in prospect, the freedom aimed at by Lucretius might perhaps be deemed a positive good. "This terror," he says, "and darkness of mind must be dispelled, not by the rays of the sun and glittering shafts of day, but by the aspect and the law of Nature." He refutes the notion that any thing can come out of nothing, or that that which is once begotten can be recalled to nothing. The first beginnings, the atoms, are indestructible, and into them all things can be dissolved at last. Bodies are partly atoms and partly combinations of atoms; but the atoms nothing can quench. They are strong in solid singleness, and by their denser combination all things can be closely packed and exhibit enduring strength. He denies that matter is infinitely divisible. We come at length to the atoms, without which, as an imperishable substratum, all order in the generation and development of things would be destroyed.

The mechanical shock of the atoms being in his view the all-sufficient cause of things, he combats the notion that the constitution of Nature has been in any way determined by intelligent design. The interaction of the atoms throughout infinite time rendered all manner of combinations possible. Of these the fit ones persisted, while the unfit ones disappeared. Not after sage deliberation did the atoms station themselves in their right places, nor did they bargain what motions they should assume. From all eternity they have been driven together, and, after trying motions and unions of every kind, they fell at length into the arrangements out of which this system of things has been formed. His grand conception of the atoms falling silently through immeasurable ranges of space and time suggested the nebular hypothesis to Kant, its first propounder. "If you will apprehend and keep in mind these things, Nature, free at once, and rid of her haughty lords, is seen to do all things spontaneously of herself, without the meddling of the gods."[2]

[1] Born 99 B. C.

[2] Monro's translation. In his criticism of this work (*Contemporary Review*, 1867) Dr. Hayman does not appear to be aware of the really sound and subtile observations on which the reasoning of Lucretius, though erroneous, sometimes rests.

During the centuries between the first of these three philosophers and the last, the human intellect was active in other fields than theirs. The Sophists had run through their career. At Athens had appeared the three men, Socrates, Plato, and Aristotle, whose yoke remains to some extent unbroken to the present hour. Within this period, also, the School of Alexandria was founded, Euclid wrote his "Elements," and he and others made some advance in optics. Archimedes had propounded the theory of the lever and the principles of hydrostatics. Pythagoras had made his experiments on the harmonic intervals, while astronomy was immensely enriched by the discoveries of Hipparchus, who was followed by the historically more celebrated Ptolemy. Anatomy had been made the basis of scientific medicine; and it is said by Draper[1] that vivisection then began. In fact, the science of ancient Greece had already cleared the world of the fantastic images of divinities operating capriciously through natural phenomena. It had shaken itself free from that fruitless scrutiny "by the internal light of the mind alone," which had vainly sought to transcend experience and reach a knowledge of ultimate causes. Instead of accidental observation, it had introduced observation with a purpose; instruments were employed to aid the senses; and scientific method was rendered in a great measure complete by the union of induction and experiment.

What, then, stopped its victorious advance? Why was the scientific intellect compelled, like an exhausted soil, to lie fallow for nearly two millenniums before it could regather the elements necessary to its fertility and strength? Bacon has already let us know one cause; Whewell ascribes this stationary period to four causes—obscurity of thought, servility, intolerance of disposition, enthusiasm of temper; and he gives striking examples of each.[2] But these characteristics must have had their causes, which lay in the circumstances of the time. Rome and the other cities of the empire had fallen into moral putrefaction. Christianity had appeared, offering the Gospel to the poor, and, by moderation if not asceticism of life, practically protesting against the profligacy of the age. The sufferings of the early Christians and the extraordinary exaltation of mind which enabled them to triumph over the diabolical tortures to which they were subjected,[3] must have left traces not easily effaced. They scorned the earth, in view of that "building of God, that house not made with hands, eternal in the heavens." The Scriptures which ministered to their spiritual needs were also the measure of their science. When, for example, the celebrated question of antipodes came to be discussed, the Bible was with many the ultimate court of appeal. Augustine, who flourished A. D. 400, would not deny the rotundity of the earth,

[1] "History of the Intellectual Development of Europe," p. 295.

[2] "History of the Inductive Sciences," vol. i.

[3] Depicted with terrible vividness in Rénan's "Antichrist."

but he would deny the possible existence of inhabitants at the other side, "because no such race is recorded in Scripture among the descendants of Adam." Archbishop Boniface was shocked at the assumption of a "world of human beings out of the reach of the means of salvation." Thus reined in, science was not likely to make much progress. Later on, the political and theological strife between the Church and civil governments, so powerfully depicted by Draper, must have done much to stifle investigation.

Whewell makes many wise and brave remarks regarding the spirit of the middle ages. It was a menial spirit. The seekers after natural knowledge had forsaken that fountain of living waters, the direct appeal to Nature by observation and experiment, and had given themselves up to the remanipulation of the notions of their predecessors. It was a time when thought had become abject, and when the acceptance of mere authority led, as it always does in science, to intellectual death. Natural events, instead of being traced to physical, were referred to moral causes, while an exercise of the fantasy, almost as degrading as the spiritualism of the present day, took the place of scientific speculation. Then came the mysticism of the middle ages, magic, alchemy, the Neo-platonic philosophy, with its visionary though sublime attractions, which caused men to look with shame upon their own bodies as hindrances to the absorption of the creature in the blessedness of the Creator. Finally came the scholastic philosophy, a fusion, according to Lange, of the least mature notions of Aristotle with the Christianity of the West. Intellectual immobility was the result. As a traveler without a compass in a fog may wander long, imagining he is making way, and find himself, after hours of toil, at his starting-point, so the schoolmen, having tied and untied the same knots, and formed and dissipated the same clouds, found themselves at the end of centuries in their old position.

With regard to the influence wielded by Aristotle in the middle ages, and which, though to a less extent, he still wields, I would ask permission to make one remark. When the human mind has achieved greatness and given evidence of extraordinary power in any domain, there is a tendency to credit it with similar power in all other domains. Thus theologians have found comfort and assurance in the thought that Newton dealt with the question of revelation, forgetful of the fact that the very devotion of his powers, through all the best years of his life, to a totally different class of ideas, not to speak of any natural disqualification, tended to render him less instead of more competent to deal with theological and historic questions. Goethe, starting from his established greatness as a poet, and indeed from his positive discoveries in natural history, produced a profound impression among the painters of Germany when he published his "Farbenlehre," in which he endeavored to overthrow Newton's theory of colors. This theory he deemed so obviously absurd, that he considered its author a charlatan, and attacked him with a corresponding vehemence of language. In the domain of natural history Goethe had made really considerable discoveries; and we have high authority for assuming that, had he devoted himself wholly to that side of science, he might have reached in it an eminence comparable with that which he attained as a poet. In sharpness of observation, in the detection of analogies, however apparently remote, in the classification and organization of facts according to the analogies discerned, Goethe possessed extraordinary powers. These elements of scientific inquiry fall in with the discipline of the poet. But, on the other hand, a mind thus richly endowed in the direction of natural history may be almost shorn of endowment as regards the more strictly called physical and mechanical sciences. Goethe was in this condition. He could not formulate distinct mechanical conceptions; he could not see the force of mechanical reasoning; and in regions where such reasoning reigns supreme he became a mere *ignis fatuus* to those who followed him.

I have sometimes permitted myself to compare Aristotle with Goethe, to credit the Stagirite with an almost superhuman power of amassing and systematizing facts, but to consider him fatally defective on that side of the mind in respect to which incompleteness has been justly ascribed to Goethe. Whewell refers the errors of Aristotle, not to a neglect of facts, but to "a neglect of the idea appropriate to the facts; the idea of mechanical cause, which is force, and the substitution of vague or inapplicable notions, involving only relations of space or emotions of wonder." This is doubtless true; but the word "neglect" implies mere intellectual misdirection, whereas in Aristotle, as in Goethe, it was not, I believe, misdirection, but sheer natural incapacity which lay at the root of his mistakes. As a physicist, Aristotle displayed what we should consider some of the worst attributes of a modern physical investigator—indistinctness of ideas, confusion of mind, and a confident use of language, which led to the delusive notion that he had really mastered his subject, while he as yet had failed to grasp even the elements of it. He put words in the place of things, subject in the place of object. He preached induction without practising it, inverting the true order of inquiry by passing from the general to the particular, instead of from the particular to the general. He made of the universe a closed sphere, in the centre of which he fixed the earth, proving from general principles, to his own satisfaction and that of the world for nearly 2,000 years, that no other universe was possible. His notions of motion were entirely unphysical. It was natural or unnatural, better or worse, calm or violent —no real mechanical conception regarding it lying at the bottom of his mind. He affirmed that a vacuum could not exist, and proved that if it did exist motion in it would be impossible. He determined *a priori* how many species of animals must exist, and showed on general principles why animals must have such and such parts. When an eminent contemporary philosopher, who is far removed from errors of this kind, remembers these abuses of the *a priori* method, he will be able to make allowance for the jealousy of physicists as to the acceptance of so-called *a priori* truths. Aristotle's errors of detail were grave and numerous. He affirmed that only in man we had the beating of the heart, that the left side of the body was colder than the right, that men have more teeth than women, and that there is an empty space, not at the front, but at the back of every man's head.

There is one essential quality in physical conceptions which was entirely wanting in those of Aristotle and his followers. I wish it could be expressed by a word untainted by its associations; it signifies a capability of being placed as a coherent picture before the mind. The Germans express the act of picturing by the word *vorstellen*, and the picture they call a *Vorstellung*. We have no word in English which comes nearer to our requirements than *imagination*, and, taken with its proper limitations, the word answers very well; but, as just intimated, it is tainted by its associations, and therefore objectionable to some minds. Compare, with reference to this capacity of mental presentation, the case of the Aristotelian, who refers the ascent of water in a pump to Nature's abhorrence of a vacuum, with that of Pascal when he proposed to solve the question of atmospheric pressure by the ascent of the Puy de Dôme. In the one case the terms of the explanation refuse to fall into place as a physical image; in the other the image is distinct, the fall and rise of the barometer being clearly figured as the balancing of two varying and opposing pressures.

During the drought of the middle ages in Christendom, the Arabian intellect, as forcibly shown by Draper, was active. With the intrusion of the Moors into Spain, cleanliness, order, learning, and refinement, took the place of their opposites. When smitten with the disease, the Christian peasant resorted to a shrine; the Moorish one to an instructed physician. The Arabs encouraged translations from the Greek philosophers, but not from the Greek poets. They turned in disgust "from the lewdness of our classical mythology, and denounced as an unpardonable blasphemy all connection between the impure Olympian Jove and the Most High God." Draper traces still further than Whewell the Arab elements in our scientific terms, and points out that the under-garment of ladies retains to this hour its Arab name. He gives examples of what Arabian men of science accomplished, dwelling particularly on Alhazen, who was the first to correct the Platonic notion that rays of light are emitted by the eye. He discovered atmospheric refraction, and points out that we see the sun and moon after they have set. He explains the enlargement of the sun and moon, and the shortening of the vertical diameters of both these bodies, when near the horizon. He is aware that the atmosphere decreases in density with increase of height, and actually fixes its height at 58½ miles. In the "Book of the Balance Wisdom," he sets forth the connection between the weight of the atmosphere and its increasing density. He shows that a body will weigh differently in a rare and a dense atmosphere. He considers the force with which plunged bodies rise through heavier media. He understands the doctrine of the centre of gravity, and applies it to the investigation of balances and steelyards. He recognizes gravity as a force, though he falls into the error of making it diminish at the distance, and of making it purely terrestrial. He knows the relation between the velocities, spaces, and times of falling bodies, and has distinct ideas of capillary attraction. He improves the hydrometer. The determination of the densities of the bodies, as given by Alhazen, approaches very closely to our own. "I join," says Draper, "in the pious prayer of Alhazen, 'that in the day of judgment the All-Merciful will take pity on the soul of Abur-Raihân, because he was the first of the race of men to construct a table of specific gravities.'" If all this be historic truth (and I have entire confidence in Dr. Draper), well may he "deplore the systematic manner in which the literature of Europe has contrived to put out of sight our scientific obligations to the Mohammedans."[1]

Toward the close of the stationary period, a word-weariness, if I may so express it, took more and more possession of men's minds. Christendom had become sick of the school philosophy and its verbal wastes, which led to no issue, but left the intellect in everlasting haze. Here and there was heard the voice of one impatiently crying in the wilderness, "Not unto Aristotle, not unto subtile hypotheses, not unto Church, Bible, or blind tradition, must we turn for a knowledge of the universe, but to the direct investigation of Nature by observation and experiment." In 1543 the epoch-making work of Copernicus on the paths of the heavenly bodies appeared. The total crash of Aristotle's closed universe with the earth at its centre followed as a consequence; and "the earth moves" became a kind of watchword among intellectual freemen. Copernicus was the Canon of the Church of Frauenburg, in the diocese of Ermeland. For three-and-thirty years he had withdrawn himself from the world, and devoted himself to the consolidation of his great scheme of the solar system. He made its blocks eternal; and even to those who feared it, and desired its overthrow, it was so obviously strong that they refrained from meddling with it. In the last year of the life of Copernicus his book appeared. It is said that the old man received a copy of it a few days before his death, and then departed in peace.

The Italian philosopher Giordano Bruno was one of the earliest converts to the new astronomy. Taking Lucretius as his exemplar,

[1] "Intellectual Development of Europe," p. 359.

he revived the notion of the infinity of worlds; and, combining with it the doctrine of Copernicus, reached the sublime generalization that the fixed stars are suns, scattered numberless through space and accompanied by satellites, which bear the same relation to them as the earth does to our sun, or our moon to our earth. This was an expansion of transcendent import; but Bruno came closer than this to our present line of thought. Struck with the problem of the generation and maintenance of organisms, and duly pondering it, he came to the conclusion that Nature in her productions does not imitate the technic of man. Her process is one of unraveling and unfolding. The infinity of forms under which matter appears was not imposed upon it by an external artificer; by its own intrinsic force and virtue it brings these forms forth. Matter is not the mere naked, 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.

This outspoken man was originally a Dominican monk. He was accused of heresy and had to fly, seeking refuge in Geneva, Paris, England, and Germany. In 1592 he fell into the hands of the Inquisition at Venice. He was imprisoned for many years, tried, degraded, excommunicated, and handed over to the civil power, with the request that he should be treated gently and "without the shedding of blood." This meant that he was to be burnt; and burnt accordingly he was, on February 16, 1600. To escape a similar fate, Galileo, thirty-three years afterward, abjured, upon his knees and with his hand on the holy gospels, the heliocentric doctrine. After Galileo came Kepler, who from his German home defied the power beyond the Alps. He traced out from preëxisting observations the laws of planetary motion. The problem was thus prepared for Newton, who bound those empirical laws together by the principle of gravitation.

During the middle ages the doctrine of atoms had to all appearance vanished from discussion. In all probability it held its ground among sober-minded and thoughtful men, though neither the Church nor the world was prepared to hear of it with tolerance. Once, in the year 1348, it received distinct expression. But retraction by compulsion immediately followed, and, thus discouraged, it slumbered till the seventeenth century, when it was revived by a contemporary of Hobbes and Descartes, the Père Gassendi.

The analytic and synthetic tendencies of the human mind exhibit themselves throughout history, great writers ranging themselves sometimes on the one side, sometimes on the other. Men of lofty feelings, and minds open to the elevating impressions produced by Nature as a whole, whose satisfaction, therefore, is rather ethical than logical, have leaned to the synthetic side; while the analytic harmonizes best with the more precise and more mechanical bias which seeks the satisfaction of the understanding. Some form of pantheism was usually adopted by the one, while a detached Creator, working more or less after the manner of men, was often assumed by the other.[1] Gassendi is hardly to be ranked with either. Having formerly acknowledged God as the first great cause, he immediately drops the idea, applies the known laws of mechanics to the atoms, and thence deduces all vital phenomena. God, who created earth and water, plants and animals, produced in the first place a definite number of atoms, which constituted the seed of all things. Then began that series of combinations and decompositions which goes on at the present day, and which will continue in the future. The principle of every change resides in matter. In artificial productions the moving principle is different from the material worked upon; but in Nature the agent works within, being the most active and mobile part of the material itself. Thus this bold ecclesiastic, without incurring the censure of the Church or the world, contrives to outstrip Mr. Darwin. The same cast of mind which caused him to detach the Creator from his universe led him also to detach the soul from the body, though to the body he ascribes an influence so large as to render the soul almost unnecessary. The aberrations of reason were in his view an affair of the material brain. Mental disease is brain-disease; but then the immortal reason sits apart, and cannot be touched by the disease. The errors of madness are errors of the instrument, not of the performer.

It may be more than a mere result of education, connecting itself probably with the deeper mental structure of the two men, that the idea of Gassendi, above enunciated, is substantially the same as that expressed by Prof. Clerk Maxwell at the close of the very noble lecture delivered by him at Bradford last year. According to both philosophers, the atoms, if I understand aright, are the *prepared materials*, the "manufactured articles," which, formed by the skill of the Highest, produce by their subsequent interaction all the phenomena of the material world. There seems to be this difference, however, between Gassendi and Maxwell: the one *postulates*, the other *infers* his first cause. In his manufactured articles, Prof. Maxwell finds the basis of an induction which enables him to scale philosophic heights considered inaccessible by Kant, and to take the logical step from the atoms to their Maker.

The atomic doctrine, in whole or in part, was entertained by Bacon, Descartes, Hobbes, Locke, Newton, Boyle, and their successors, until the chemical law of multiple proportions enabled Dalton to confer upon it an entirely new significance. In our day there are secessions from the theory, but it still stands firm. Only a year or two ago Sir William Thomson, with characteristic penetration, sought

[1] Boyle's model of the universe was the Strasbourg clock with an outside artificer. Goethe, on the other hand, sang:

"Ihm ziemt's die Welt im Innern zu bewegen,
Natur in sich, sich in Natur zu hegen."

The same repugnance to the clockmaker conception is manifest in Carlyle.

to determine the sizes of the atoms, or rather to fix the limits between which their sizes lie; while only last year the discourses of Williamson and Maxwell illustrate the present hold of the doctrine upon the foremost scientific minds. What these atoms, self-moved and self-posited, can and cannot accomplish in relation to life, is at the present moment the subject of profound scientific thought. I doubt the legitimacy of Maxwell's logic; but it is impossible not to feel the ethic glow with which his lecture concludes. There is, moreover, a Lucretian grandeur in his description of the steadfastness of the atoms: "Natural causes, as we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built, the foundation-stones of the material universe, remain unbroken and unworn."

Ninety years subsequent to Gassendi the doctrine of bodily instruments, as it may be called, assumed immense importance in the hands of Bishop Butler, who, in his famous "Analogy of Religion," developed, from his own point of view, and with consummate sagacity, a similar idea. The bishop still influences superior minds; and it will repay us to dwell for a moment on his views. He draws the sharpest distinction between our real selves and our bodily instruments. He does not, as far as I remember, use the word soul, possibly because the term was so hackneyed in his day, as it had been for many generations previously. But he speaks of "living powers," "perceiving" or "percipient powers," "moving agents," "ourselves," in the same sense as we should employ the term soul. He dwells upon the fact that limbs may be removed and mortal diseases assail the body, while the mind, almost up to the moment of death, remains clear. He refers to sleep and to swoon, where the "living powers" are suspended but not destroyed. He considers it quite as easy to conceive of an existence out of our bodies as in them; that we may animate a succession of bodies, the dissolution of all of them having no more tendency to dissolve our real selves, or "deprive us of living faculties—the faculties of perception and action—than the dissolution of any foreign matter which we are capable of receiving impressions from, or making use of, for the common occasions of life." This is the key of the bishop's position: "Our organized bodies are no more a part of ourselves than any other matter around us." In proof of this he calls attention to the use of glasses, which "prepare objects" for the "percipient power" exactly as the eye does. The eye itself is no more percipient than the glass, and is quite as much the instrument of the true self, and also as foreign to the true self, as the glass is. "And if we see with our eyes only in the same manner as we do with glasses, the like may justly be concluded from analogy of all our senses."

Lucretius, as you are aware, reached a precisely opposite conclusion; and it certainly would be interesting, if not profitable, to us all, to hear what he would or could urge in opposition to the reasoning of the bishop. As a brief discussion of the point will enable us to see the bearings of an important question, I will here permit a disciple of Lucretius to try the strength of the bishop's position, and then allow the bishop to retaliate, with the view of rolling back, if he can, the difficulty upon Lucretius. Each shall state his case fully and frankly, and you shall be umpire between them. The argument might proceed in this fashion:

"Subjected to the test of mental presentation (*Vorstellung*) your views, most honored prelate, would present to many minds a great, if not an insuperable difficulty. You speak of 'living powers,' 'percipient or perceiving powers,' and 'ourselves;' but can you form a mental picture of any one of these apart from the organism through which it is supposed to act? Test yourself honestly, and see whether you possess any faculty that would enable you to form such a conception. The true self has a local habitation in each of us; thus localized, must it not possess a form? If so, what form? Have you ever for a moment realized it? When a leg is amputated, the body is divided into two parts; is the true self in both of them or in one? Thomas Aquinas might say in both; but not you, for you appeal to the consciousness associated with one of the two parts to prove that the other is foreign matter. Is consciousness, then, a necessary element of the true self? If so, what do you say to the case of the whole body being deprived of consciousness? If not, then on what grounds do you deny any portion of the true self to the severed limb? It seems very singular that, from the beginning to the end of your admirable book (and no one admires its sober strength more than I do), you never once mention the brain or nervous system. You begin at one end of the body, and show that its parts may be removed without prejudice to the perceiving power. What if you begin at the other end, and remove, instead of the leg, the brain? The body, as before, is divided into two parts; but both are now in the same predicament, and neither can be appealed to to prove that the other is foreign matter. Or, instead of going so far as to remove the brain itself, let a certain portion of its bony covering be removed, and let a rhythmic series of pressure and relaxations of pressure be applied to the soft substance. At every pressure 'the faculties of perception and of action' vanish; at every relaxation of pressure they are restored. Where, during the intervals of pressure, is the perceiving power? I once had the discharge of a Leyden battery passed unexpectedly through me: I felt nothing, but was simply blotted out of conscious existence for a sensible interval. Where was my true self during that interval? Men who have recovered from lightning-stroke have been much longer in the same state; and, indeed, in cases of ordinary concussion of the brain, days may elapse during which no experience is registered in consciousness. Where is the man himself during the period of insensibility? You may say that I beg the question when I assume the man to have been unconscious, that he was really conscious all the time, and has simply forgotten what had occurred to him. In reply to this, I can only say that no one need shrink from the worst tortures that superstition ever invented if only so felt and so remembered. I do not think your theory of instruments goes at all to the bottom of the matter. A telegraph operator has his instruments, by means of which he converses with the world; our bodies possess a nervous system, which plays a similar part between the perceiving powers and external things. Cut the wires of the operator, break his battery, demagnetize his needle; by this means you certainly sever his connection with the world; but, inasmuch as these are real instruments, their destruction does not touch the man who uses them. The operator survives, *and he knows that he survives.* What is it, I would ask, in the human system that answers to this conscious survival of the operator when the battery of the brain is so disturbed as to produce insensibility, or when it is destroyed altogther?

"Another consideration, which you may consider slight, presses upon me with some force. The brain may change from health to disease, and through such a change the most exemplary man may be converted into a debauchee or a murderer. My very noble and approved good master had, as you know, threatenings of lewdness introduced into his brain by his jealous wife's philter; and, sooner than permit himself to run even the risk of yielding to these base promptings, he slew himself. How could the hand of Lucretius have been thus turned against himself if the real Lucretius remained as before? Can the brain or can it not act in this distempered way without the intervention of the immortal reason? If it can, then it is a prime mover which requires only healthy regulation to render it reasonably self-acting, and there is no apparent need of your immortal reason at all. If it cannot, then the immortal reason, by its mischievous activity in operating upon a broken instrument, must have the credit of committing every imaginable extravagance and crime. I think, if you will allow me to say so, that the gravest consequences are likely to flow from your estimate of the body. To regard the brain as you would a staff or an eyeglass—to shut your eyes to all its mystery, to the perfect correlation that reigns between its condition and our consciousness, to the fact that a slight excess or defect of blood in it produces that very swoon to which you refer, and that in relation to it our meat and drink and air and exercise have a perfectly transcendental value and significance—to forget all this does, I think, open a way to innumerable errors in our habits of life, and may possibly in some cases initiate and foster that very disease, and consequent mental ruin, which a wiser appreciation of this mysterious organ would have avoided."

I can imagine the bishop thoughtful after hearing this argument. He was not the man to allow anger to mingle with the consideration of a point of this kind. After due consideration, and having strengthened himself by that honest contemplation of the facts which was habitual with him, and which includes the desire to give even adverse facts their due weight, I can suppose the bishop to proceed thus: "You will remember that in the 'Analogy of Religion,' of which you have so kindly spoken, I did not profess to prove any thing absolutely, and that I over and over again acknowledged and insisted on the smallness of our knowledge, or rather the depth of our ignorance, as regards the whole system of the universe. My object was to show my deistical friends who set forth so eloquently the beauty and beneficence of Nature and the Ruler thereof, while they had nothing but scorn for the so-called absurdities of the Christian scheme, that they were in no better condition than we were, and that for every difficulty they found upon our side, quite as great a difficulty was to be found on theirs. I will now, with your permission, adopt a similar line of argument. You are a Lucretian, and from the combination and separation of atoms deduce all terrestrial things, including organic forms and their phenomena. Let me tell you in the first instance how far I am prepared to go with you. I admit that you can build crystalline forms out of this play of molecular force; that the diamond, amethyst, and snow-star, are truly wonderful structures which are thus produced. I will go further and acknowledge that even a tree or flower might in this way be organized. Nay, if you can show me an animal without sensation, I will concede to you that it also might be put together by the suitable play of molecular force.

"Thus far our way is clear, but now comes my difficulty. Your atoms are individually without sensation, much more are they without intelligence. May I ask you, then, to try your hand upon this problem? Take your dead hydrogen-atoms, your dead oxygen-atoms, your dead carbon-atoms, your dead nitrogen-atoms, your dead phosphorus-atoms, and all the other atoms, dead as grains of shot, of which the brain is formed. Imagine them separate and sensationless; observe them running together and forming all imaginable combinations. This, as a purely mechanical process, is *seeable* by the mind. But can you see, or dream, or in any way imagine, how out of that mechanical act, and from these individually dead atoms, sensation, thought, and emotion, are to arise? You speak of the difficulty of presentation in my case; is it less in yours? I am not all bereft of this *Vorstellungskraft* of which you speak. I can follow a particle of musk until it reaches the olfactory nerve; I can follow the waves of sound until their tremors reach the water of the labyrinth, and set the otoliths and Corti's fibres in motion; I can also visualize the waves of ether as they cross the eye and hit the retina. Nay, more, I am able to follow up to the central organ the motion thus imparted at the periphery, and to see in idea the very molecules of the brain thrown into tremors. My insight is not baffled by these physical processes. What baffles me, what I find unimaginable, transcending every faculty I possess—transcending, I humbly submit, every faculty *you* possess—is the notion that out of those physical tremors you can extract things so utterly incongruous with them as sensation, thought, and emotion. You may say, or think, that this issue of consciousness from the clash of atoms is not more incongruous than the flash of light from the union of oxygen and hydrogen. But I beg to say that it is. For such incongruity as the flash possesses is that which I now force upon your attention. The flash is an affair of consciousness, the objective counterpart of which is a vibration. It is a flash only by our interpretation. *You* are the cause of the apparent incongruity; and *you* are the thing that puzzles me. I need not remind you that the great Leibnitz felt the difficulty which I feel, and that to get rid of this monstrous deduction of life from death he displaced your atoms by his monads, and which were more or less perfect mirrors of the universe, and out of the summation and integration of which he supposed all the phenomena of life—sentient, intellectual, and emotional—to arise.

"Your difficulty, then, as I see you are ready to admit, is quite as great as mine. You cannot satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which materialism must inevitably split whenever it pretends to be a complete philosophy of life. What is the moral, my Lucretian? You and I are not likely to indulge in ill-temper in the discussion of these great topics, where we see so much room for honest differences of opinion. But there are people of less wit, or more bigotry (I say it with humility), on both sides, who are ever ready to mingle anger and vituperation with such discussions. There are, for example, writers of note and influence at the present day who are not ashamed to assume the 'deep personal sin' of a great logician to be the cause of his unbelief in a theologic dogma. And there are others who hold that we, who cherish our noble Bible, wrought as it has been into the constitution of our forefathers, and by inheritance into us, must necessarily be hypocritical and insincere. Let us disavow and discountenance such people, cherishing the unswerving faith that what is good and true in both our arguments will be preserved for the benefit of humanity, while all that is bad or false will disappear."

It is worth remarking that in one respect the bishop was a product of his age. Long previous to his day the nature of the soul had been so favorite and general a topic of discussion that, when the students of the University of Paris wished to know the leanings of a new professor, they at once requested him to lecture upon the soul. About the time of Bishop Butler the question was not only agitated but extended. It was seen by the clear-witted men who entered this arena that many of their best arguments applied equally to brutes and men. The bishop's arguments were of this character. He saw it, admitted it, accepted the consequences, and boldly embraced the whole animal world in his scheme of immortality.

Bishop Butler accepted with unwavering trust the chronology of the Old Testament, describing it as "confirmed by the natural and civil history of the world, collected from common historians, from the state of the earth, and from the late inventions of arts and sciences." These words mark progress; they must seem somewhat hoary to the Bishop's successors of to-day.[1] It is hardly necessary to inform you that, since his time, the domain of the naturalist has been immensely extended—the whole science of geology, with its astounding revelations regarding the life of the ancient earth, having been created. The rigidity of old conceptions has been relaxed, the public mind being rendered gradually tolerant of the idea that not for six thousand, nor for sixty thousand, nor for six thousand thousand, but for æons embracing untold millions of years, this earth has been the theatre of life and death. The riddle of the rocks has been read by the geologist and paleontologist, from sub-Cambrian depths to the deposits thickening over the sea-bottoms of to-day. And upon the leaves of that stone-book are, as you know, stamped the characters, plainer and surer than those formed by the ink of history, which carry the mind back into abysses of past time, compared with which the periods which satisfied Bishop Butler cease to have a visual angle. Everybody now knows this; all men admit it; still, when they were first broached, these verities of science found loud-tongued denunciators, who proclaimed not only their baselessness considered scientifically, but their immorality considered as questions of ethics and religion: the Book of Genesis had stated the question in a different fashion, and science must necessarily go to pieces when it clashed with this authority. And as the seed of the thistle produces a thistle, and nothing else, so these objectors scatter their germs abroad, and reproduce their kind, ready to play again the part of their intellectual progenitors, to show the same virulence, the same ignorance, to achieve for a time the same success, and finally to suffer the same inexorable defeat. Sure the time must come at last when human nature in its entirety, whose legitimate demands it is admitted science alone cannot satisfy, will find interpreters and expositors of a different stamp from those rash and ill-informed persons who have been hitherto so ready to hurl themselves against every new scientific revelation, lest it should endanger what they are pleased to consider theirs.

[1] Only to some; for there are dignitaries who even now speak of the earth's rocky crust as so much building-material prepared for man at the Creation. Surely it is time that this loose language should cease.

The lode of discovery once struck, those petrified forms in which life was at one time active increased to multitudes and demanded classification. The general fact soon became evident that none but the simplest forms of life lie lowest down—that as we climb higher and higher among the superimposed strata more perfect forms appear. The change, however, from form to form was not continuous, but by steps, some small, some great. "A section," says Mr. Huxley, "a hundred feet thick will exhibit at different heights a dozen species of ammonite, none of which passes beyond its particular zone of limestone, or clay, into the zone below it, or into that above it." In the presence of such facts it was not possible to avoid the question, Have these forms, showing, though in broken stages and with many irregularities, this unmistakable general advance, been subjected to no continuous law of growth or variation? Had our education been purely scientific, or had it been sufficiently detached from influences which, however ennobling in another domain, have always proved hindrances and delusions when introduced as factors into the domain of physics, the scientific mind never could have swerved from the search for a law of growth, or allowed itself to accept the anthropomorphism which regarded each successive stratum as a kind of mechanic's bench for the manufacture of new species out of all relation to the old.

Biased, however, by their previous education, the great majority of naturalists invoked a special creative act to account for the appearance of each new group of organisms. Doubtless there were numbers who were clear-headed enough to see that this was no explanation at all; that, in point of fact, it was an attempt, by the introduction of a greater difficulty, to account for a less. But, having nothing to offer in the way of explanation, they for the most part held their peace. Still the thoughts of reflecting men naturally and necessarily simmered round the question. De Maillet, a contemporary of Newton, has been brought into notice by Prof. Huxley as one who "had a notion of the modifiability of living forms." In my frequent conversations with him, the late Sir Benjamin Brodie, a man of highly-philosophic mind, often drew my attention to the fact that, as early as 1794, Charles Darwin's grandfather was the pioneer of Charles Darwin. In 1801, and in subsequent years, the celebrated Lamarck, who produced so profound an impression on the public mind through the vigorous exposition of his views by the author of "Vestiges of Creation," endeavored to show the development of species out of changes of habit and external condition. In 1813, Dr. Wells, the founder of our present theory of dew, read before the Royal Society a paper in which, to use the words of Mr. Darwin, "he distinctly recognizes the principle of natural selection; and this is the first recognition that has been indicated." The thoroughness and skill with which Wells pursued his work, and the obvious independence of his character, rendered him long ago a favorite with me; and it gave me the liveliest pleasure to alight upon this additional testimony to his penetration. Prof. Grant, Mr. Patrick Matthew, Von Buch, the author of the "Vestiges," D'Halloy, and others,[1] by the enunciation of views more or less clear and correct, showed that the question had been fermenting long prior to the year 1858, when Mr. Darwin and Mr. Wallace simultaneously, but independently, placed their closely concurrent views upon the subject before the Linnean Society.

These papers were followed in 1859 by the publication of the first edition of "The Origin of Species." All great things come slowly to the birth. Copernicus, as I informed you, pondered his great work for thirty-three years. Newton for nearly twenty years kept the idea of Gravitation before his mind; for twenty years also he dwelt upon his discovery of Fluxions, and doubtless would have continued to make it the object of his private thought had he not found that Liebnitz was upon his track. Darwin for two-and-twenty years pondered the problem of the origin of species, and doubtless he would have continued to do so had he not found Wallace upon his track.[2] A concentrated but full and powerful epitome of his labors was the consequence. The book was by no means an easy one; and probably not one in every score of those who then attacked it had read its pages through, or was competent to grasp their significance if they had. I do not say this merely to discredit them, for there were in those days some really eminent scientific men, entirely raised above the heat of popular prejudice, willing to accept any conclusion that science had to offer, provided it was duly backed by fact and argument, and who entirely mistook Mr. Darwin's views. In fact, the work needed an expounder, and it found one in Mr. Huxley. I know nothing more admirable in the way of scientific exposition than those early articles of his on the origin of species. He swept the curve of discussion through the really significant points of the subject, enriched his exposition with profound original remarks and reflections, often summing up in a single pithy sentence an argument which a less compact mind would have spread over pages. But there is one impression made by the book itself which no exposition of it, however luminous, can convey, and that is the impression of the vast amount of labor, both of observation and of thought, implied in its production. Let us glance at its principles.

It is conceded on all hands that what are called varieties are continually produced. The rule is probably without exception. No chick and no child is in all respects and particulars the counterpart of its brother or sister; and in such differences we have "variety" incipient. No naturalist could tell how far this variation could be carried; but

[1] In 1855, Mr. Herbert Spencer ("Principles of Psychology," second edition, vol. i., p. 465) expressed "the belief that life under all its forms has arisen by an unbroken evolution, and through the instrumentality of what are called natural causes."

[2] The behavior of Mr. Wallace in relation to this subject has been dignified in the highest degree.

the great mass of them held that never by any amount of internal or external change, nor by the mixture of both, could the offspring of the same progenitor so far deviate from each other as to constitute different species. The function of the experimental philosopher is to combine the conditions of Nature and to produce her results; and this was the method of Darwin.[1] He made himself acquainted with what could, without any manner of doubt, be done in the way of producing variation. He associated himself with pigeon-fanciers—bought, begged, kept, and observed every breed that he could obtain. Though derived from a common stock, the diversities of these pigeons were such that "a score of them might be chosen which, if shown to an ornithologist, and he were told that they were wild birds, would certainly be ranked by him as well-defined species." The simple principle which guides the pigeon-fancier, as it does the cattle-breeder, is the selection of some variety that strikes his fancy, and the propagation of this variety by inheritance. With his eye still upon the particular appearance which he wishes to exaggerate, he selects it as it reappears in successive broods, and thus adds increment to increment until an astonishing amount of divergence from the parent type is effected. Man in this case does not produce the *elements* of the variation. He simply observes them, and, by selection, adds them together until the required result has been obtained. "No man," says Mr. Darwin, "would ever try to make a fantail till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter until he saw a pigeon with a crop of unusual size." Thus Nature gives the hint, man acts upon it, and, by the law of inheritance, exaggerates the deviation.

Having thus satisfied himself by indubitable facts that the organization of an animal or of a plant (for precisely the same treatment applies to plants) is to some extent plastic, he passes from variation under domestication to variation under Nature. Hitherto we have dealt with the adding together of small changes by the conscious selection of man. Can Nature thus select? Mr. Darwin's answer is, "Assuredly she can." The number of living things produced is far in excess of the number that can be supported; hence at some period or other of their lives there must be a struggle for existence; and what is the infallible result? If one organism were a perfect copy of the other in regard to strength, skill, and agility, external conditions would decide. But this is not the case. Here we have the fact of variety offering itself to Nature, as in the former instance it offered itself to man; and those varieties which are least competent to cope with surrounding conditions will infallibly give way to those that are competent. To use a familiar proverb, the weakest comes to the wall. But the triumphant fraction again breeds to over-production, trans-

[1] The first step only toward experimental demonstration has been taken. Experiments now begun might, a couple of centuries hence, furnish data of incalculable value, which ought to be supplied to the science of the future.

mitting the qualities which secured its maintenance, but transmitting them in different degrees. The struggle for food again supervenes, and those to whom the favorable quality has been transmitted in excess will assuredly triumph. It is easy to see that we have here the addition of increments favorable to the individual still more rigorously carried out than in the case of domestication; for not only are unfavorable specimens not selected by Nature, but they are destroyed. This is what Mr. Darwin calls "Natural Selection," which "acts by the preservation and accumulation of small inherited modifications, each profitable to the preserved being." With this idea he interpenetrates and leavens the vast store of facts that he and others have collected. We cannot, without shutting our eyes through fear or prejudice, fail to see that Darwin is here dealing, not with imaginary, but with true causes; nor can we fail to discern what vast modifications may be produced by natural selection in periods sufficiently long. Each individual increment may resemble what mathematicians call a "differential" (a quantity indefinitely small); but definite and great changes may obviously be produced by the integration of these infinitesimal quantities through practically infinite time.

If Darwin, like Bruno, rejects the notion of creative power acting after human fashion, it certainly is not because he is unacquainted with the numberless exquisite adaptations on which this notion of a supernatural artificer has been founded. His book is a repository of the most startling facts of this description. Take the marvelous observation which he cites from Dr. Crüger, where a bucket with an aperture, serving as a spout, is formed in an orchid. Bees visit the flower: in eager search of material for their combs they push each other into the bucket, the drenched ones escaping from their involuntary bath by the spout. Here they rub their backs against the viscid stigma of the flower and obtain glue; then against the pollen-masses, which are thus stuck to the back of the bee and carried away. "When the bee, thus provided, flies to another flower, or to the same flower a second time, and is pushed by his comrades into the bucket, and then crawls out by the passage, the pollen-mass upon its back necessarily comes first into contact with the viscid stigma," which takes up the pollen; and this is how that orchid is fertilized. Or take this other case of the *Catasetum*. "Bees visit these flowers in order to gnaw the labellum; on doing this they inevitably touch a long, tapering, sensitive projection. This, when touched, transmits a sensation or vibration to a certain membrane, which is instantly ruptured, setting free a spring, by which the pollen-mass is shot forth like an arrow in the right direction, and adheres by its viscid extremity to the back of the bee." In this way the fertilizing pollen is spread abroad.

It is the mind thus stored with the choicest materials of the teleologist that rejects teleology, seeking to refer these wonders to natural causes. They illustrate, according to him, the method of Nature, not the "technic" of a man-like Artificer. The beauty of flowers is due to natural selection. Those that distinguish themselves by vividly contrasting colors from the surrounding green leaves are most readily seen, most frequently visited by insects, most often fertilized, and hence most favored by natural selection. Colored berries also readily attract the attention of birds and beasts, which feed upon them, and spread their manured seeds abroad, thus giving trees and shrubs possessing such berries a greater chance in the struggle for existence.

With profound analytic and synthetic skill, Mr. Darwin investigates the cell-making instinct of the hive-bee. His method of dealing with it is representative. He falls back from the more perfectly to the less perfectly developed instinct—from the hive-bee to the humble-bee, which uses its own cocoon as a comb, and to classes of bees of intermediate skill, endeavoring to show how the passage might be gradually made from the lowest to the highest. The saving of wax is the most important point in the economy of bees. Twelve to fifteen pounds of dry sugar are said to be needed for the secretion of a single pound of wax. The quantities of nectar necessary for the wax must therefore be vast; and every improvement of constructive instinct which results in the saving of wax is a direct profit to the insect's life. The time that would otherwise be devoted to the making of wax is now devoted to the gathering and storing of honey for winter food. He passes from the humble-bee, with its rude cells, through the Melipona with its more artistic cells, to the hive-bee with its astonishing architecture. The bees place themselves at equal distances apart upon the wax, sweep and excavate equal spheres round the selected points. The spheres intersect, and the planes of intersection are built up with thin laminæ. Hexagonal cells are thus formed. This mode of treating such questions is, as I have said, representative. He habitually retires from the more perfect and complex, to the less perfect and simple, carries you with him through stages of perfecting, adds increment to increment of infinitesimal change, and in this way gradually breaks down your reluctance to admit that the exquisite climax of the whole could be a result of natural selection.

Mr. Darwin shirks no difficulty; and, saturated as the subject was with his own thought, he must have known, better than his critics, the weakness as well as the strength of his theory. This, of course, would be of little avail were his object a temporary dialectic victory instead of the establishment of a truth which he means to be everlasting. But he takes no pains to disguise the weakness he has discerned; nay, he takes every pains to bring it into the strongest light. His vast resources enable him to cope with objections started by himself and others, so as to leave the final impression upon the reader's mind that if they be not completely answered they certainly are not fatal. Their negative force being thus destroyed, you are free to be influenced by the vast positive mass of evidence he is able to bring before you. This largeness of knowledge and readiness of resource render Mr. Darwin the most terrible of antagonists. Accomplished naturalists have leveled heavy and sustained criticisms against him—not always with the view of fairly weighing his theory, but with the express intention of exposing its weak points only. This does not irritate him. He treats every objection with a soberness and thoroughness which even Bishop Butler might be proud to imitate, surrounding each fact with its appropriate detail, placing it in its proper relations, and usually giving it a significance which, as long as it was kept isolated, failed to appear. This is done without a trace of ill-temper. He moves over the subject with the passionless strength of a glacier; and the grinding of the rocks is not always without a counterpart in the logical pulverization of the objector. But, though, in handling this mighty theme, all passion has been stilled, there is an emotion of the intellect incident to the discernment of new truth which often colors and warms the pages of Mr. Darwin. His success has been great; and this implies not only the solidity of his work, but the preparedness of the public mind for such a revelation. On this head a remark of Agassiz impressed me more than any thing else. Sprung from a race of theologians, this celebrated man combated to the last the theory of natural selection. One of the many times I had the pleasure of meeting him in the United States was at Mr. Winthrop's beautiful residence at Brookline, near Boston. Rising from luncheon, we all halted, as if by a common impulse, in front of a window, and continued there a discussion which had been started at table. The maple was in its autumn glory; and the exquisite beauty of the scene outside seemed, in my case, to interpenetrate without disturbance the intellectual action. Earnestly, almost sadly, Agassiz turned and said to the gentlemen standing round: "I confess that I was not prepared to see this theory received as it has been by the best intellects of our time. Its success is greater than I could have thought possible."

In our day great generalizations have been reached. The theory of the origin of species is but one of them. Another, of still wider grasp and more radical significance, is the doctrine of the Conservation of Energy, the ultimate philosophical issues of which are as yet but dimly seen—that doctrine which "binds Nature fast in fate" to an extent not hitherto recognized, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connection which, as far as the human understanding has yet pierced, asserts itself everywhere in Nature. Long in advance of all definite experiment upon the subject, the constancy and indestructibility of matter had been affirmed; and all subsequent experience justified the affirmation. Later researches extended the attribute of indestructibility to force. This idea, applied in the first instance to inorganic, rapidly embraced organic Nature. The vegetable world, though drawing almost all its nutriment from invisible sources, was proved incompetent to generate anew either matter or force. Its matter is for the most part transmuted air; its force transformed solar force. The animal world was proved to be equally uncreative, all its motive energies being referred to the combustion of its food. The activity of each animal as a whole was proved to be the transferred activities of its molecules. The muscles were shown to be stores of mechanical force, potential until unlocked by the nerves, and then resulting in muscular contractions. The speed at which messages fly to and fro along the nerves was determined, and found to be, not as had been previously supposed, equal to that of light or electricity, but less than the speed of a flying eagle.

This was the work of the physicist: then came the conquests of the comparative anatomist and physiologist, revealing the structure of every animal, and the function of every organ in the whole biological series, from the lowest zoophyte up to man. The nervous system had been made the object of profound and continued study, the wonderful and, at bottom, entirely mysterious controlling power which it exercises over the whole organism, physical and mental, being recognized more and more. Thought could not be kept back from a subject so profoundly suggestive. Besides the physical life dealt with by Mr. Darwin, there is a psychical life presenting similar gradations, and asking equally for a solution. How are the different grades and orders of mind to be accounted for? What is the principle of growth of that mysterious power which on our planet culminates in Reason? These are questions which, though not thrusting themselves so forcibly upon the attention of the general public, had not only occupied many reflecting minds, but had been formally broached by one of them before the "Origin of Species" appeared.

With the mass of materials furnished by the physicist and physiologist in his hands, Mr. Herbert Spencer, twenty years ago, sought to graft upon this basis a system of psychology; and two years ago a second and greatly-amplified edition of his work appeared. Those who have occupied themselves with the beautiful experiments of Plateau, will remember that, when two spherules of olive-oil, suspended in a mixture of alcohol-and-water of the same density as the oil, are brought together, they do not immediately unite. Something like a pellicle appears to be formed around the drops, the rupture of which is immediately followed by the coalescence of the globules into one. There are organisms whose vital actions are almost as purely physical as that of these drops of oil. They come into contact and fuse themselves thus together. From such organisms to others a shade higher, and from these to others a shade higher still, and on through an ever-ascending series, Mr. Spencer conducts his argument. There are two obvious factors to be here taken into account—the creature and the medium in which it lives, or, as it is often expressed, the organism and its environment. Mr. Spencer's fundamental principle is, that between these two factors there is incessant interaction. The organism is played upon by the environment, and is modified to meet the requirements of the environment. Life he defines to be "a continuous adjustment of internal relations to external relations."

In the lowest organisms we have a kind of tactual sense diffused over the entire body; then, through impressions from without and their corresponding adjustments, special portions of the surface become more responsive to stimuli than others. The senses are nascent, the basis of all of them being that simple tactual sense which the sage Democritus recognized 2,300 years ago as their common progenitor. The action of light, in the first instance, appears to be a mere disturbance of the chemical processes in the animal organism, similar to that which occurs in the leaves of plants. By degrees the action becomes localized in a few pigment-cells, more sensitive to light than the surrounding tissue. The eye is here incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed as the interception of the light is in almost all cases by the contact of the closely-adjacent, opaque body, sight in this condition becomes a kind of "anticipatory touch." The adjustment continues; a slight bulging out of the epidermis over the pigment-granules supervenes. A lens is incipient, and, through the operation of infinite adjustments, at length reaches the perfection that it displays in the hawk and the eagle. So of the other senses; they are special differentiations of a tissue which was originally vaguely sensitive all over.

With the development of the senses the adjustments between the organism and its environment gradually extend in *space*, a multiplication of experiences and a corresponding modification of conduct being the result. The adjustments also extend in *time*, covering continually greater intervals. Along with this extension in space and time, the adjustments also increase in specialty and complexity, passing through the various grades of brute-life and prolonging themselves into the domain of reason. Very striking are Mr. Spencer's remarks regarding the influence of the sense of touch upon the development of intelligence. This is, so to say, the mother-tongue of all the senses, into which they must be translated to be of service to the organism. Hence its importance. The parrot is the most intelligent of birds, and its tactual power is also greatest. From this sense it gets knowledge unattainable by birds which cannot employ their feet as hands. The elephant is the most sagacious of quadrupeds—its tactual range and skill, and the consequent multiplication of experiences, which it owes to its wonderfully adaptable trunk, being the basis of its sagacity. Feline animals, for a similar cause, are more sagacious than hoofed animals—atonement being to some extent made, in the case of the horse, by the possession of sensible prehensile lips. In the *Primates* the evolution of intellect and the evolution of tactual appendages go hand in hand. In the most intelligent anthropoid apes we find the tactual range and delicacy greatly augmented, new avenues of knowledge being thus opened to the animal. Man crowns the edifice here, not only in virtue of his own manipulatory power, but through the enormous extension of his range of experience, by the invention of instruments of precision, which serve as supplemental senses and supplemental limbs. The reciprocal action of these is finely described and illustrated. That chastened intellectual emotion to which I have referred in connection with Mr. Darwin is, I should say, not absent in Mr. Spencer. His illustrations possess at times exceeding vividness and force, and from his style on such occasions it is to be inferred that the ganglia of this apostle of the understanding are sometimes the seat of a nascent poetic thrill.

It is a fact of supreme importance that actions, the performance of which at first requires even painful effort and deliberation, may, by habit, be rendered automatic. Witness the slow learning of its letters by a child, and the subsequent facility of reading in a man, when each group of letters which forms a word is instantly and without effort fused to a single perception. Instance the billiard-player, whose muscles of hand and eye, when he reaches the perfection of his art, are unconsciously coördinated. Instance the musician, who, by practice, is enabled to fuse a multitude of arrangements, auditory, tactual, and muscular, into a process of automatic manipulation. Combining such facts with the doctrine of hereditary transmission, we reach a theory of instinct. A chick, after coming out of the egg, balances itself correctly, runs about, picks up food, thus showing that it possesses a power of directing its movements to definite ends. How did the chick learn this very complex coördination of eye, muscles, and beak? It has not been individually taught; its personal experience is *nil;* but it has the benefit of ancestral experience. In its inherited organization are registered all the powers which it displays at birth. So also as regards the instinct of the hive-bee already referred to. The distance at which the insects stand apart when they sweep their hemispheres and build their cells is "organically remembered." Man also carries with him the physical texture of his ancestry, as well as the inherited intellect bound up with it. The defects of intelligence during infancy and youth are probably less due to a lack of individual experience than to the fact that in early life the cerebral organization is still incomplete. The period necessary for completion varies with the race, and with the individual. As a round shot outstrips a rifled one on quitting the muzzle of the gun, so the lower race in childhood may outstrip the higher. But the higher eventually overtakes the lower, and surpasses it in range. As regards individuals, we do not always find the precocity of youth prolonged to mental power in maturity; while the dullness of boyhood is sometimes strikingly contrasted with the intellectual energy of after-years. Newton, when a boy, was weakly, and he showed no particular aptitude at school; but in his eighteenth year he went to Cambridge, and soon afterward astonished his teachers by his power of dealing with geometrical problems. During his quiet youth his brain was slowly preparing itself to be the organ of those energies which he subsequently displayed.

By myriad blows (to use a Lucretian phrase) the image and superscription of the external world are stamped as states of consciousness upon the organism, the depth of the impression depending upon the number of the blows. When two or more phenomena occur in the environment invariably together, they are stamped to the same depth or to the same relief, and indissolubly connected. And here we come to the threshold of a great question. Seeing that he could in no way rid himself of the consciousness of Space and Time, Kant assumed them to be necessary "forms of thought," the moulds and shapes into which our intuitions are thrown, belonging to ourselves solely and without objective existence. With unexpected power and success Mr. Spencer brings the hereditary-experience theory, as he holds it, to bear upon this question. "If there exist certain external relations which are experienced by all organisms at all instants of their waking lives—relations which are absolutely constant and universal—there will be established answering internal relations that are absolutely constant and universal. Such relations we have in those of Space and Time. As the substratum of all other relations of the Non-Ego, they must be responded to by conceptions that are the substrata of all other relations in the Ego. Being the constant and infinitely repeated elements of thought, they must become the automatic elements of thought—the elements of thought which it is impossible to get rid of—the 'forms of intuition.'"

Throughout this application and extension of the "Law of Inseparable Association," Mr. Spencer stands on totally different ground from Mr. John Stuart Mill, invoking the registered experiences of the race instead of the experiences of the individual. His overthrow of Mr. Mill's restriction of experience is, I think, complete. That restriction ignores the power of organizing experience furnished at the outset to each individual; it ignores the different degrees of this power possessed by different races and by different individuals of the same race. Were there not in the human brain a potency antecedent to all experience, a dog or cat ought to be as capable of education as a man. These predetermined internal relations are independent of the experiences of the individual. The human brain is the "organized register of infinitely numerous experiences received during the evolution of life, or rather during the evolution of that series of organisms through which the human organism has been reached. The effects of the most uniform and frequent of these experiences have been successively bequeathed, principal and interest, and have slowly mounted to that high intelligence which lies latent in the brain of the infant. Thus it happens that the European inhabits from twenty to thirty cubic inches more of brain than the Papuan. Thus it happens that faculties, as of music, which scarcely exist in some inferior races, become congenital in superior ones. Thus it happens that out of savages unable to count up to the number of their fingers, and speaking a language containing only nouns and verbs, arise at length our Newtons and Shakespeares."

At the outset of this address it was stated that physical theories which lie beyond experience are divided by a process of abstraction from experience. It is instructive to note from this point of view the successive introduction of new conceptions. The idea of the attraction of gravitation was preceded by the observation of the attraction of iron by a magnet, and of light bodies by rubbed amber. The polarity of magnetism and electricity appealed to the senses; and thus became the substratum of the conception that atoms and molecules are endowed with definite, attractive, and repellent poles, by the play of which definite forms of crystalline architecture are produced. Thus molecular force becomes *structural.* It required no great boldness of thought to extend its play into organic Nature, and to recognize in molecular force the agency by which both plants and animals are built up. In this way, out of experience arise conceptions which are wholly ultra-experiential.

The *origination* of life is a point lightly touched upon, if at all, by Mr. Darwin and Mr. Spencer. Diminishing gradually the number of progenitors, Mr. Darwin comes at length to one "primordial form;" but he does not say, as far as I remember, how he supposes this form to have been introduced. He quotes with satisfaction the words of a celebrated author and divine who had "gradually learned to see that it is just as noble a conception of the Deity to believe He created a few original forms, capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of his laws." What Mr. Darwin thinks of this view of the introduction of life I do not know. Whether he does or does not introduce his "primordial form" by a creative act, I do not know. But the question will inevitably be asked, "How came the form there?" With regard to the diminution of the number of created forms, one does not see that much advantage is gained by it. The anthropomorphism, which it seemed the object of Mr. Darwin to set aside, is as firmly associated with the creation of a few forms as with the creation of a multitude. We need clearness and thoroughness here. 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 scientific 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.

The "materialism" here enunciated may be different from what you suppose, and I therefore crave your gracious patience to the end. "The question of an external world," says Mr. J. S. Mill, "is the great battle-ground of metaphysics."[1] Mr. Mill himself reduces external phenomena to "possibilities of sensation." Kant, as we have seen, made time and space "forms" of our own intuitions. Fichte, having first by the inexorable logic of his understanding proved himself to be a mere link in that chain of eternal causation which holds so rigidly in Nature, violently broke the chain by making Nature, and all that it inherits, an apparition of his own mind.[2] And it is by no means easy to combat such notions. For, when I say I see you, and that I have not the least doubt about it, the reply is, that what I am really conscious of is an affection of my own retina. And if I urge

[1] "Examination of Hamilton," p. 154. [2] "Bestimmung des Menschen."

that I can check my sight of you by touching you, the retort would be that I am equally transgressing the limits of fact; for what I am really conscious of is, not that you are there, but that the nerves of my hand have undergone a change. All we hear, and see, and touch, and taste, and smell, are, it would be urged, mere variations of our own condition, beyond which, even to the extent of a hair's breadth, we cannot go. That any thing answering to our impressions exists outside of ourselves is not a *fact*, but an *inference*, to which all validity would be denied by an idealist like Berkeley, or by a skeptic like Hume. Mr. Spencer takes another line. With him, as with the uneducated man, there is no doubt or question as to the existence of an external world. But he differs from the uneducated, who think that the world really *is* what consciousness represents it to be. Our states of consciousness are mere *symbols* of an outside entity which produces them and determines the order of their succession, but the real nature of which we can never know.[1] In fact, the whole process of evolution is the manifestation of a Power absolutely inscrutable to the intellect of man. As little in our day as in the days of Job, can man, by searching, find this Power out. Considered fundamentally, it is by the operation of an insoluble mystery that life is evolved, species differentiated, and mind unfolded from their prepotent elements in the immeasurable past. There is, you will observe, no very rank materialism here.

The strength of the doctrine of evolution consists, not in an experimental demonstration (for the subject is hardly accessible to this mode of proof), but in its general harmony with the method of Nature as hitherto known. From contrast, moreover, it derives enormous relative strength. On the one side we have a theory (if it could with any propriety be so called) derived, as were the theories referred to at the beginning of this address, not from the study of Nature, but from the observation of men—a theory which converts the Power whose garment is seen in the visible universe into an Artificer, fashioned after the human model, and acting by broken efforts as man is seen to act. On the other side we have the conception that all we see around us,

[1] In a paper, at once popular and profound, entitled "Recent Progress in the Theory of Vision," contained in the volume of lectures by Helmholtz published by Longmans, this symbolism of our states of consciousness is also dwelt upon. The impressions of sense are the mere *signs* of external things. In this paper Helmholtz contends strongly against the view that the consciousness of space is inborn; and he evidently doubts the power of the chick to pick up grains of corn without some preliminary lessons. On this point, he says, further experiments are needed. Such experiments have been since made by Mr. Spalding, aided, I believe, in some of his observations by the accomplished and deeply-lamented Lady Amberley; and they seem to prove conclusively that the chick does not need a single moment's tuition to teach it to stand, run, govern the muscles of its eyes, and peck. Helmholtz, however, is contending against the notion of preëstablished harmony: and I am not aware of his views as to the organization of experiences of race or breed.

and all we feel within us—the phenomena of physical Nature as well as those of the human mind—have their unsearchable roots in a cosmical life, if I dare apply the term, an infinitesimal span of which only is offered to the investigation of man. And even this span is only knowable in part. We can trace the development of a nervous system, and correlate with it the parallel phenomena of sensation and thought. We see with undoubting certainty that they go hand in hand. But we try to soar in a vacuum the moment we seek to comprehend the connection between them. An Archimedean fulcrum is here required which the human mind cannot command; and the effort to solve the problem, to borrow an illustration from an illustrious friend of mine, is like the effort of a man trying to lift himself by his own waistband. All that has been here said is to be taken in connection with this fundamental truth. When "nascent senses" are spoken of, when "the differentiation of a tissue at first vaguely sensitive all over" is spoken of, and when these processes are associated with "the modification of an organism by its environment," the same parallelism, without contact, or even approach to contact, is implied. There is no fusion possible between the two classes of facts—no motor energy in the intellect of man to carry it without logical rupture from the one to the other.

Further, the doctrine of evolution derives man, in his totality, from the interaction of organism and environment through countless ages past. The human understanding, for example—the faculty which Mr. Spencer has turned so skillfully round upon its own antecedents—is itself a result of the play between organism and environment through cosmic ranges of time. Never surely did prescription plead so irresistible a claim. But then it comes to pass that, over and above his understanding, there are many other things appertaining to man whose prescriptive rights are quite as strong as that of the understanding itself. It is a result, for example, of the play of organism and environment that sugar is sweet and that aloes are bitter, that the smell of henbane differs from the perfume of a rose. Such facts of consciousness (for which, by-the-way, no adequate reason has ever yet been rendered) are quite as old as the understanding itself, and many other things can boast an equally ancient origin. Mr. Spencer at one place refers to that most powerful of passions—the amatory passion—as one which, when it first occurs, is antecedent to all relative experience whatever, and we may pass its claim as being at least as ancient and as valid as that of the understanding itself. Then there are such things woven into the texture of man as the feeling of awe, reverence, wonder—and not alone the sexual love just referred to, but the love of the beautiful, physical and moral, in Nature, poetry, and art. There is also that deep-set feeling which, since the earliest dawn of history, and probably for ages prior to all history, incorporated itself in the religions of the world. You who have escaped from these religions in the high-and-dry light of the understanding may deride them; but in so doing you deride accidents of form merely, and fail to touch the immovable basis of the religious sentiment in the emotional nature of man. To yield this sentiment reasonable satisfaction is the problem of problems at the present hour. And grotesque in relation to scientific culture as many of the religions of the world have been and are—dangerous, nay, destructive, to the dearest privileges of freemen as some of them undoubtedly have been, and would, if they could, be again—it will be wise to recognize them as the forms of force, mischievous, if permitted to intrude on the region of *knowledge*, over which it holds no command, but capable of being guided by liberal thought to noble issues in the region of *emotion*, which is its proper sphere. 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?

The impregnable position of science may be described in a few words. All religious theories, schemes, and systems, which embrace notions of cosmogony, or which otherwise reach into its domain, must, in so far as they do this, submit to the control of science, and relinquish all thought of controlling it. Acting otherwise proved disastrous in the past, and it is simply fatuous to-day. Every system which would escape the fate of an organism too rigid to adjust itself to its environment, must be plastic to the extent that the growth of knowledge demands. When this truth has been thoroughly taken in, rigidity will be relaxed, exclusiveness diminished, things now deemed essential will be dropped, and elements now rejected will be assimilated. The lifting of the life is the essential point, and as long as dogmatism, fanaticism, and intolerance, are kept out, various modes of leverage may be employed to raise life to a higher level. Science itself not unfrequently derives motive-power from an ultra-scientific source. Whewell speaks of enthusiasm of temper as a hindrance to science; but he means the enthusiasm of weak heads. There is a strong and resolute enthusiasm in which science finds an ally; and it is to the lowering of this fire rather than to a diminution of intellectual insight, that the lessening productiveness of men of science in their mature years is to be ascribed. Mr. Buckle sought to detach intellectual achievement from moral force. He gravely erred; for, without moral force to whip it into action, the achievements of the intellect would be poor indeed.

It has been said that science divorces itself from literature. The statement, like so many others, arises from lack of knowledge. A glance at the less technical writings of its leaders—of its Helmholtz, its Huxley, and its Du Bois-Reymond—would show what breadth of literary culture they command. Where among modern writers can you find their superiors in clearness and vigor of literary style? Science desires no isolation, but freely combines with every effort toward the bettering of man's estate. Single-handed, and supported not by outward sympathy, but by inward force, it has built at least one great wing of the many-mansioned home which man in his totality demands. And if rough walls and protruding rafter-ends indicate that on one side the edifice is still incomplete, it is only by wise combination of the parts required with those already irrevocably built that we can hope for completeness. There is no necessary incongruity between what has been accomplished and what remains to be done. The moral glow of Socrates, which we all feel by ignition, has in it nothing incompatible with the physics of Anaxagoras which he so much scorned, but which he would hardly scorn to-day. And here I am reminded of one among us, hoary, but still strong, whose prophet-voice some thirty years ago, far more than any other of this age, unlocked whatever of life and nobleness lay latent in its most gifted minds—one fit to stand beside Socrates or the Maccabean Eleazar, and to dare and suffer all that they suffered and dared—fit, as he once said of Fichte, "to have been the teacher of the Stoa, and to have discoursed of beauty and virtue in the groves of Academe." With a capacity to grasp physical principles, which his friend Goethe did not possess, and which even total lack of exercise has not been able to reduce to atrophy, it is the world's loss that he, in the vigor of his years, did not open his mind and sympathies to science, and make its conclusions a portion of his message to mankind. Marvelously endowed as he was—equally equipped on the side of the heart and of the understanding—he might have done much toward teaching us how to reconcile the claims of both, and to enable them in coming times to dwell together in unity of spirit and in the bond of peace.

And now the end is come. With more time, or greater strength and knowledge, what has been here said might have been better said, while worthy matters here omitted might have received fit expression. But there would have been no material deviation from the views set forth. As regards myself, they are not the growth of a day; and as regards you, I thought you ought to know the environment which, with or without your consent, is rapidly surrounding you, and in relation to which some adjustment on your part may be necessary. A hint of Hamlet's, however, teaches us all how the troubles of common life may be ended; and it is perfectly possible for you and me to purchase intellectual peace at the price of intellectual death. The world is not without refuges of this description; nor is it wanting in persons who seek their shelter and try to persuade others to do the same. I would exhort you to refuse such shelter, and to scorn such base repose—to accept, if the choice be forced upon you, commotion before stagnation, the leap of the torrent before the stillness of the swamp. In the one there is at all events life, and therefore hope; in the other, none. I have touched on debatable questions, and led you over dangerous ground—and this partly with the view of telling you, and through you the world, that as regards these questions science claims unrestricted right of search. It is not to the point to say that the views of Lucretius and Bruno, of Darwin and Spencer, may be wrong. Here I should agree with you, deeming it indeed certain that these views will undergo modification. But the point is, that, whether right or wrong, we claim the freedom to discuss them. The ground which they cover is scientific ground; and the right claimed is one made good through tribulation and anguish, inflicted and endured in darker times than ours, but resulting in the immortal victories which science has won for the human race. I would set forth equally the inexorable advance of man's understanding in the path of knowledge, and the unquenchable claims of his emotional nature which the understanding can never satisfy. The world embraces not only a Newton, but a Shakespeare—not only a Boyle, but a Raphael—not only a Kant, but a Beethoven—not only a Darwin, but a Carlyle. Not in each of these, but in all, is human nature whole. They are not opposed, but supplementary—not mutually exclusive, but reconcilable. And if, still unsatisfied, the human mind, with the yearning of a pilgrim for his distant home, will turn to the mystery from which it has emerged, seeking so to fashion it as to give unity to thought and faith, so long as this is done, not only without intolerance or bigotry of any kind, but with the enlightened recognition that ultimate fixity of conception is here unattainable, and that each succeeding age must be held free to fashion the mystery in accordance with its own needs—then, in opposition to all the restrictions of materialism, I would affirm this to be a field for the noblest exercise of what, in contrast with the *knowing* faculties, may be called the *creative* faculties of man. Here, however, I must quit a theme too great for me to handle, but which will be handled by the loftiest minds ages after you and I, like streaks of morning cloud, shall have melted into the infinite azure of the past.

THE AQUARIUM.

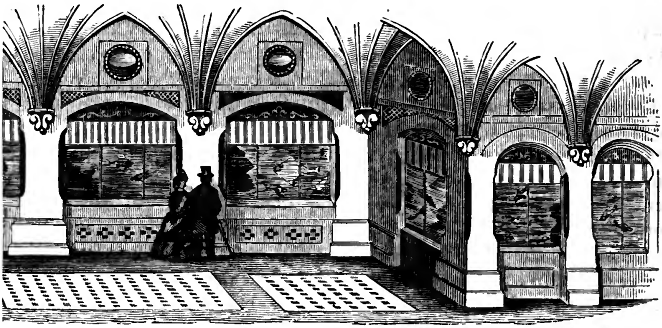
BY WILLIAM E. SIMMONS, JR.

IT is a subject for regret, as well from a national as a scientific point of view, that, while London, Paris, Berlin, Hamburg, Naples, Brighton, in fact nearly every European city of note, has its aquarium, or aquaria, New York, the metropolis of the New World, is as yet without one. True, the necessity has not been overlooked; but, beyond the agitation of the subject, no practical steps have, I believe, been taken in the matter. To the conductors of APPLETONS' JOURNAL belongs the honor of having first directed public attention to the necessity for establishing an aquarium at Central Park, and their praiseworthy efforts to that end have received, besides the very general approval of the daily press, encomiums from Prof. Henry and other eminent scientific men. Indeed, in the latter part of 1873, they even opened the way for securing to the enterprise the valuable services of Mr. W. Saville Kent, late Curator of the Brighton Aquarium. Unfortunately, during the delay that has subsequently occurred in the development of the scheme, Mr. Kent has been induced to accept the curatorship of the Manchester (England) Aquarium.

But of what use, it may be asked, other than embellishment, is the aquarium? The scientific reader, knowing its value, will not require an answer; but, to the unscientific, it doubtless seems of small practical use to spend time and money in gathering together a few fish and plants, that their growth and movements may be observed. The answer is, first, its scientific value. Its influence would be to engender in the thousands who would daily visit it a taste for scientific knowledge and pursuits. In seeing the objects it contained, people would naturally find a desire to know something of them beyond what can be learned by cursory observation, and thus be led to scientific reading and scientific education. Second, it constitutes a science by itself, and therefore demands the same encouragement that is given to any other one science. It is not yet half a century since Madame Jeannette Power began the study of marine animals, by the aid of glass cases filled with water, in which she confined them; still almost our entire knowledge of aquatic zoology having been obtained through the aquarium rests upon it. A striking result, recently obtained, is at least a partial settlement of the vexed question whether fish hear; the observations of Mr. Henry Lee on that subject, in the Brighton Aquarium, having determined that some fish certainly do hear.

In addition to these very cogent reasons is the fact that the aquarium is a never-failing source of interest. The objects it presents are, many of them, entirely new to human sight, and not a few are wonderfully beautiful. So great is the attraction of the aquarium, that, wherever established as a pecuniary investment, it has never failed to yield the most profitable results. Thus the aquarium at Hamburg has proved an immense pecuniary success; and that at Brighton, although beginning its existence so recently as August, 1872, has nevertheless already made a gratifying return to its proprietors.

FIG. 1.



MAIN TANK, BRIGHTON AQUARIUM (Half-Section).

The aquarium further serves to illustrate an important biological truth—one of the most subtile relations between the animal and vegetable kingdoms. That truth is, that the two kingdoms exert complementary influences upon the atmosphere we breathe. Plants inhale carbon and exhale oxygen; animals do the reverse. Strike out all the plants from existence, and we should, poisoned by our own breath, die in heaps, with other animals; while, if all the animals could, at one blow, be swept away from the earth into space, the plants would be destroyed by the want of carbon. And now the aquarium, which, properly speaking, is an artificial sea, or lake, possessing all the conditions necessary to the maintenance of aquatic life, both animal and vegetable, beautifully illustrates this truth. Who has not observed that fish, confined in water without plants, quickly die, unless the water be repeatedly changed? The fish die because, having breathed out all the oxygen of the water, as there is nothing in it to produce any more, they become poisoned with the suffocating carbon. But, when the plants also are put in, they take up the carbon from the fish and go on producing oxygen all the while, so there is no longer any necessity for changing the water. The fact that marine aquaria do not require the introduction of plants has been supposed by some observers to furnish a contradiction of the truth just stated. But the contradiction is apparent only, not real. Sea, or "salt" water, as it is usually called, contains a great quantity of little germs or "spores," which quickly develop microscopic vegetation or *confervæ* upon the sides of the aquarium, and upon the rocks within it. This vegetation, although unobtrusive, performs all the work done by the more conspicuous plants of the fresh-water aquarium. The credit of inventing the aquarium proper has generally been given to Madame Power, before alluded to, who, in the year 1832 and thereabouts, while studying the marine animals on the coast of Sicily, brought into use the "water-cage" to facilitate her investigations. But Mr. W. Alford Lloyd, the present Curator of the Crystal Palace Aquarium, London, who is one of the highest authorities on the subject, contradicts that view. In an article published in *Science Gossip*, several years ago, he says that the introduction into the "water-cage" of "plants *for the avowed purpose stated beforehand*, of preserving the purity of the sea-water, and of sustaining the animals in health, is due to Mrs. Thynne, who experimented in London, in 1846, on living madrepores." Madame Power, it appears, was in the habit of changing the water in her cages. It would seem, therefore, that while to Madame Power belongs the credit of furnishing the clew to the scientific value of the aquarium, to Mrs. Thynne belongs that of inventing the aquarium itself.

Some interesting facts, not wholly of a zoological nature, have been observed through the aquarium. Thus it was ascertained that objects through the medium of water appear shorter than they really are. At the distance of a few feet, a fish, or other object, appears about one-fifth shorter than it is. Mr. Lloyd, through *Science Gossip*, has made known some curious effects of electricity on fish. A friend of his had a large fresh-water garden-aquarium. One day, during a thunder-storm, a house, about 200 feet from the aquarium, was struck by lightning. At the moment of the flash, all the fish in the aquarium, forty-three in number, of various kinds, were suddenly suspended perpendicularly, heads downward, with their tails at the surface of the water, in which position they feebly and vainly endeavored to swim to the bottom of the tank. "The manner in which the eels were almost jerked out of their hiding-places, in the sand at the bottom of the tank, was very remarkable. In less than half an hour forty-one were dead, strongly curved, almost in the form of semicircles, and fast decomposing; but two gradually recovered, by being placed in running water. It is well known that when fish become sick and die, under ordinary circumstances, they turn belly upward, horizontally, instead of having nose downward, as in this case."

These facts sufficiently indicate the utility of the aquarium, and the necessity for having one at Central Park. As an indication of the interest commanded by the subject in England, it may be mentioned that Mr. Kent has begun a series of lectures at Manchester, to show how it subserves the purposes of scientific instruction. The first lecture was delivered on the last Friday in June to a fairly numerous audience, and another will follow on every Friday afternoon during the summer.

One of the largest and most successful aquaria anywhere is that at Brighton, England. It is a private enterprise, and of very recent origin. It was originated by Mr. Edward Birch, an English engineer of note, who organized a stock company with a capital of $400,000. The work of construction was begun in 1869, and the building was formally thrown open to the public in August, 1872. The building stands upon the sea-beach, in front of the Marine Parade, its roof being a little below the level of that promenade. It has a total length of 715 feet, with a width of 100 feet. The interior is divided into two corridors, on either side of which stand the tanks containing the fish. The dominant style of architecture is the Italian, and highly ornate. The roof of the corridors is arched and groined, "constructed of variegated bricks, and supported on columns of Bath stone, polished serpentine marble, and Aberdeen granite. The capital of each column is elaborately carved in some appropriate marine device, while the floor, in correspondence, is laid out in acrostic tiles." The tanks number forty-one. Their fronts are made of plate-glass, one inch thick, divided into sheets three feet wide and six feet high, supported by upright iron mullions. At the eastern end of the west or main corridor is a fernery, with rock-work and cascade. Many of the tanks are also supplied with ornamental rock-work. For the accommodation of visitors there are a restaurant, dining-hall, and reading-room, in the building. The smallest tank measures 11 feet long by 10 broad, and contains about 4,000 gallons of water, while the largest measures 130 feet long, 30 broad, and holds 110,000 gallons. The latter is large enough to accommodate a small whale. At present, however, it contains only a porpoise, a few dog-fish, a ray, and several turtle. Six tanks are devoted to fresh-water animals, the rest to marine. The water of the latter is pumped up from the sea by steam when needed, but is never changed in any of the tanks except when required by turbidity, or any accident, such as the cracking of a front. To secure abundant aëration each tank is supplied with several vulcanite tubes, entering at the top and descending to the bottom. An air-pump, situated at one end of the building, and worked by steam, forces a stream of air into the tank through each tube. The result is, a constant bubbling up of the water. This plan, however, does not seem to be as desirable or efficient as the circulatory system maintained at the Crystal Palace Aquarium. This consists in merely pumping the water by steam up to a higher level, and allowing it to return, by force of gravity, through the tanks to the reservoir beneath. In its course it takes up a greater amount of oxygen than can be otherwise imparted to it, and at the same time acquires great clearness and brilliancy.

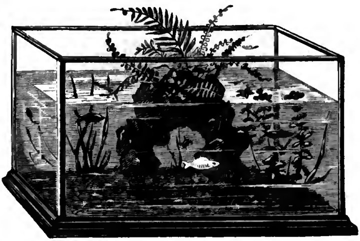
The best kind of vessel for a small aquarium is an oblong tank made of slate, with a glass front. Glass may be used instead of slate, but the latter is desirable, because it is important that the light received into the aquarium should be admitted from above, while the dark sides and back give a more natural appearance to the occupants. The framework, if of iron, should be plated to prevent its rusting, as that would injure the plants and animals. If the parts are cemented, Portland cement should be used, as it is freer from impurities than other cements; however, even it should be soaked in water for several days previous to using. In the form of an aquarium, superficial area

Fig. 2.

Cheap Aquarium.

is more important than depth, because, the larger the surface in proportion to the depth, the greater will be the quantity of oxygen absorbed by the water. For household purposes, the cheapest and most convenient vessel for a small aquarium is the common bell-shaped glass used by confectioners to cover cakes. When this is used, green paper should be pasted upon the outside, except on the front, from the level of the water to the bottom. For marine aquaria the bottom should rise a short distance from the front, and continue in an inclined plane to the surface of the water. The bottom of the aquarium should be covered with a layer of sand from one to two inches thick, upon the top of which should be placed a few pebbles, in patches. For marine aquaria, the sand must be procured from the sea-beach, or a river-side, below the tide-mark, and, for those of fresh water, from the bed of a brook or running stream, and, in either case, it must be thoroughly washed, to free it from impurities. Rock-work may be built upon the sand, to form caves and grottoes, but there should not be any hiding-places for impurities to collect in. A pleasing effect is secured by building the rock-work above the surface of the water, and making a small hollow in the top, where a fern may be planted. The rock should be taken from the sea, or the brook, according as it is wanted for the marine or fresh-water aquarium, the object being to make the artificial home of the animals as much as possible like their natural one. In constructing the rock-work, Portland cement should be used, and it should be allowed to harden before the water is poured into the tank. The water should be poured off several times, until it remains quite clean, and the greatest care should be taken to prevent the addition of impurities with any object. The plants must be stuck into the sand with a pebble tied to the roots of each to hold it in position, and they should be arranged to produce a pleasing effect, as individual taste may dictate. After the plants have taken root, the animals may be added. If both forms of life be present in proper proportions, there will be no necessity for change or disturbance of the water, but, if they be not, artificial aëration will be required. When this is needed, the

Fig. 3.

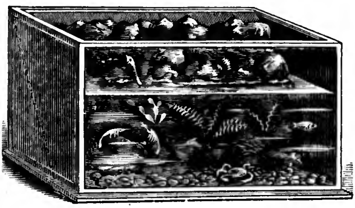


Fresh-water Aquarium.

fish will repeatedly rise to the surface and stick their noses out to catch a breath of oxygen. Aëration may be effected in lifting the water by cupsful, and allowing it to run back gradually from a point two or three feet above. This process should be continued for a half-hour or more at a time, once or twice a day. The ordinary level of the water should be indicated by a mark on the glass-front, so that loss from evaporation can be detected and supplied. Great care must be taken to secure uniformity of temperature, between 45° and 65° Fahr. For this purpose an east window should be chosen where the sun can be had for two or three hours every morning. In summer the window should be opened, and in the winter evenings the tank drawn back into the room. A south window may be used for the aquarium if care be taken to shade off the noonday sun. When the water at the bottom of the tank becomes impure from the accumulation of sediment, it may be drawn off by a siphon (of rubber tube) without disturbing the water above, after which the tank must be filled up again with pure water. For the purpose of removing large substances from the bottom, a pair of wooden forceps—glove-stretchers will do—are required. Light particles, such as uneaten food, decayed leaves, etc., can be removed by placing against them one end of a small glass tube, and covering the other with a finger. The aquarium should be kept as clean as possible, all dead plants or animals being at once removed.

The best plants for fresh-water aquaria are the spiral *Valisneria*, a native of Southern Europe, and not easily procurable; the American water-thyme (*Anacharis alsinastrum*); the common frogbit (*Hydrocharis morsus-ranæ*), which, being of different form from the others, will give variety in appearance; the arum (*Calla palustris*); common stonewort (*Chara vulgaris*); water-soldier (*Stratiotes alvidies*); spiked water-milfoil (*Myriophyllum spicatum*); small water-lilies (for larger tanks), white (*Nymphea alba*), and yellow (*Nuphar buteum*). A little duckweed (*Lemna minor*) may be added, as it floats about and harbors minute insects which the fish eat. In choosing animals for the same, the golden carp is most desirable for its beauty, the minnow for interest and longevity. The latter should be examined before admission

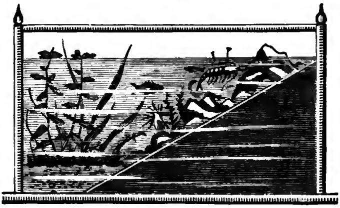
Fig. 4.



Marine Aquarium (Front View).

and rejected if a white downy spot is observed near the tail, as that is an indication of disease. The loach, the common carp, Prussian carp, roach, tench, and gudgeon, may be admitted, but the first three are preferable to the last. The common tadpole possesses considerable interest in its development into the frog. The small newt and the triton are objects of interest and quite harmless. The latter has a bright-yellow body striped with black. When amphibious animals, such as the newt and frog, are kept, the rock-work must rise above the surface of the water, as these animals require a resting-place above water. Small floats may be prepared for them by smearing a cork with marine glue and sprinkling it with sand. When the glue has dried, place the float in water and allow it to remain there for some time before putting it into the aquarium. These animals have also a disposition to rove, which must be checked by covering the aquarium. The cover should be of glass and flat, with a large opening in the centre. The cover is also advantageous to keep out dust. Molluscous animals, as the horny coil-shell (*Planorbis corneus*) and the pond mud-shell (*Limnea stagnalis*), may be added. They are both to be found among the grasses that grow in ponds and on the margin of brooks. Such insects as the common water-spider (*Argyroneta aquatica*), the large harmless beetle (*Hydroüs piceus*), and the little whirligig (*Gyrinus natator*), can be introduced to advantage. Pugnacious individuals, as the perch and the stickleback, though interesting, are not desirable objects for a general aquarium. The best food for the animals described is a little biscuit-powder kneaded into pills about the size of a pin-head and fine shreds of raw beef cut with scissors. The first should be fed once a day, the biscuit and meat being thrown in bit by bit alternately.

Fig. 5.



Marine Aquarium (Side View).

The marine aquarium must be supplied with sea-water taken not less than a mile from shore, or from the middle of a large river. When any is lost from the tank *by evaporation*, add fresh rain-water to supply the deficiency; losses otherwise occasioned must be made good by the addition of sea-water. Among the most curious and interesting animals are the shrimp or prawn; the smooth anemone (*Actinia mesembryanthemum*), one of the hardiest and most curious animals that can be found; the limpet (*Patella vulgaris*), with its shelly parasite the barnacle (*Balanus*); the hermit-crab (*Pagurus Bernhardus*); the stone-crab (*Cancer pagurus*); the smaller star-fish; and the tube-worm (*Surpulæ*). In introducing fish, care should be taken to select the most amicable; a small shark, for instance, was once introduced into the aquarium of the Emperor William, at his country-seat in Prussia. The effect was, that all the other fish forsook the tank, and fled in great confusion into a fresh-water one adjoining, nor could they be driven back until the shark was removed. The best food for the animals indicated is the mussel or the oyster cut into fine shreds, but fresh beef may be used if these cannot be had. To feed the anemones, place a shred upon the end of a stick and put it in contact with one of the animal's tentacles, whereupon it will be immediately conveyed to the mouth. They do not require feeding oftener than once a week. The crabs should be fed at the same time or they will rob the anemones. It is not necessary, as previously indicated, to add plants to marine aquaria; however, a few pieces of sea-weed may be put in for the sake of ornament, but, as it does not live long, care should be taken to remove each piece as soon as it dies, and replace it by a living one.

THERMAL DEATH-POINT OF LIVING MATTER.[1]

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I.

WATER is boiling merrily over a brisk fire, when some luckless person upsets the vessel, so that the heated fluid exercises its scathing influence upon an uncovered portion of the body—hand, arm, or face. Those who have seen much of the effects produced upon the human skin by such accidents, will have acquired information not unworthy of influencing their opinion on some more general problems connected with the action of heat upon living matter. Here, at all events, there is no room for doubt. Boiling water unquestionably exercises a most pernicious and rapidly destructive action upon the living matter of which we are composed. There is no need to appeal to the sufferer's sensations for this information. This, indeed, is a point of view which we may for the present dismiss. For, however agonizing these sensations may be, they could only supply us with information upon a collateral point with which we are not at present concerned. Apart from such subjective effects, there are objective effects. That is, we are easily able to see the changes produced by boiling water upon living matter—revealing themselves as they do by an immediately altered appearance of the skin, and by the terrible wound so quickly produced. Upon these distressing, though, unfortunately, only too familiar consequences of the action of heat upon living matter, it is not necessary for me further to dwell; I would merely have the reader so far bear them in mind that they may not be incapable of recall during the perusal of this article. The occasional revival of such impressions may perhaps prove a little

[1] From author's advance sheets.

instructive to some who may chance to be at all dubious as to the destructive effects of boiling water upon lower organisms.

Probably, however, some of my readers may already be possessed by the notion that the disastrous effects just referred to are consequences following rather from the fact of the high organization of man's tissues than from any intrinsic incompatibility of nature between living matter and boiling water. The thought is natural enough and not unjustifiable. On the other hand, it will not do to attach much importance to it. Let us for a moment consider the effects produced upon an ordinary hen's egg by a brief immersion in boiling water. Here we have the "white," composed of albumen, similar to that which enters so largely into the composition of living tissues, turned from a clear fluid into an opaque solid; and we have the "yelk," made up of a dense aggregation of the simplest living units, also more or less solidified. In spite of the investing calcareous shell, these very obvious and destructive effects can be produced upon this large egg or germ by an exposure for three or four minutes to the influence of boiling water. Yet the living matter in this case is so simple that it possesses next to no organization—it is so little vitalized that it can only be considered to be half alive.

The conclusion would seem, therefore, to force itself upon us that there is something intrinsically deleterious in the action of boiling water upon living matter—whether this living matter be of high or of low organization.

This subject is one of great importance in many respects, so that it may repay us to look into the evidence bearing upon it with some degree of care. It is of great practical importance, for instance, in reference to the process of disinfection by heat, where we have to do with articles of furniture or wearing apparel used by a person suffering from a contagious disease. Because, in such a case, what we ought undoubtedly to know is, whether the temperature of boiling water, or even some lower temperature, suffices to kill any living particles which may act as so-called "germs of disease." This is a subject upon which there should be no room for doubt. Again, from a purely scientific point of view, the question is of equal cogency because of its bearing upon one of the most momentous problems in biological science—namely, that of the Origin of Life. It is on this latter account, more especially, that I now take up the inquiry as to the grade or degree of heat which proves destructive to different kinds of living matter.

A preliminary word of explanation, therefore, must be given concerning the bearings of this question upon the Origin of Life problem.

It is at present very generally admitted, upon the strength of well-known experiments, that living matter will appear and grow rapidly in hermetically-sealed flasks containing certain fluids, after the flasks and their contents have been thoroughly raised to the temperature of boiling water for ten minutes or more. These experiments we may mentally label as series A. Other experiments, which we may similarly label series B, had also shown that a brief exposure in the moist state to a temperature considerably below the boiling-point of water, is destructive to all kinds of living matter submitted to its influence. The experiments of series A, therefore, taken in conjunction with those of series B, must (if the latter results are as reliable as the former) be held to prove that living matter can originate independently, or *de novo*, through the mere productive properties of certain infusions or solutions.

If the facts are true, is it possible to stave off the conclusion? While the candid reader is asking himself this question, I may further point out to him that, as the previously discredited results belonging to series A are no longer denied, doubt is now only possible upon a subject hitherto supposed to be settled—namely, as to whether living matter is really killed by exposure in the moist state to a temperature of 212° Fahr. Obviously, at such a juncture, it rested more especially with the panspermatists, who chose still to be opponents of "spontaneous generation," to show that this belief concerning the destructive efficacy of boiling water, upon the truth of which they had previously relied, was erroneous—seeing that the advocates of spontaneous generation had demonstrated the truth of their position with reference to experiments A. Should the panspermatists fail to produce this evidence as to the untruthfulness of their old view, they must not expect to hear that they have the best of the argument; and still less will they be able to hold their ground if, while abstaining themselves from all experiments belonging to series B, their scientific opponents do make careful investigations in this direction, and arrive at the conclusion that not only was the old opinion right as to the destructive action of boiling water, but that living matter unaccustomed to the influence of heat is killed by a brief exposure even to the much lower temperature of 140° Fahr.

This is the present aspect of the problem, and those most interested in it may remember that knowledge would not advance in the rapid way which it does, were it not for the fact that the difficulties of one generation of men often disappear before the clearer, because more unprejudiced, vision of the next. Growing gradually more familiarized with the facts, those who come after us will be more and more influenced by them, and at the same time less warped by theoretical considerations already out of harmony with our present state of knowledge. We are now in a stage of transition. We are gradually learning to accept the doctrines of Evolution, as applicable to different departments of knowledge, though, as is so frequently the case when new doctrines are being adopted, this transition is being effected by many in a partial manner—they, unconsciously perhaps, endeavor to make a sort of compromise, trying to retain some of their most deeply-rooted convictions and mix them harmoniously with new views. Metallic mercury, however, will not mix with water, and there is a similar incompatibility between the explanations of the panspermatists and our present state of knowledge in regard to the question of the Origin of Life.

It remains for me now, therefore, to trace the different steps by which we have arrived at our present knowledge concerning the destructive effects of heat upon living matter. And to do this effectually I must refer my readers to good work done in the latter third of the last century by the acute and learned Abbé Spallanzani, while he was engaged in promulgating panspermatist doctrines against the views of our own countryman Needham, who, in those days, steadfastly proclaimed the truth and reality of "spontaneous generation"—though the philosophical doctrines by which he was influenced caused him to limit the acceptation of the phrase to what we now understand by the term *heterogenesis*.

I refer first of all to the work of Spallanzani, partly because he alone, of all those who have adopted panspermatist views and have taken part in this controversy, has fairly and fully faced the question of the degree of heat which proves fatal to various living things, by making it the subject of direct investigation. Others who have since defended similar views (including Pasteur in France, and Huxley and Sanderson in this country) have not made the thermal death-point of living matter a special subject of investigation, and have more or less distinctly confounded the issues of this question with that of the cognate though really distinct problem, as to whether certain infusions could themselves prove mother-liquids, and give independent birth to living matter. Dire confusion has thus been produced. A problem of a very simple nature has been made to appear very complex, while those who are able clearly to understand the real nature of the question at issue are left to marvel why the followers of Spallanzani have never ventured frankly to deal with the question of the limits of vital resistance to heat. Certainly they have displayed, to say the least, a strange sluggishness in reference to this exceedingly important problem. But apart from the fact that no panspermatist, or declared opponent of spontaneous generation, since the time of Spallanzani, has fully and directly experimented upon this subject, I am all the more induced to call the reader's attention to the abbé's treatment of it because, with some few exceptions, his investigations were conducted in a manner which cannot be improved upon at the present day, and because his reasonings upon the subject are characterized by great sagacity and fairness—allowance being made for the actual state of knowledge in his time. The work of the learned abbé to which I shall especially refer is entitled, in the admirable French translation by

Jean Senebier, "*Opuscules de Physique, Animale et Végétale*," the translation itself having been published at Geneva in 1767.

Reflecting upon the import of the experiments of his own that he had just recorded, in which living organisms were found in closed vessels containing infusions of certain vegetable seeds after these closed vessels had been immersed in boiling water for half, or, in some cases, nearly three-quarters of an hour, Spallanzani frankly avows (p. 48) that if the first of the new organisms had not come into being by some such independent method as that suggested by Needham, they must have appeared either because certain "germs" from which they had been derived had been able to resist the destructive influence of boiling water for nearly three-quarters of an hour, or because, after the cooling of the closed vessels, some of the organisms observed had passed from the air through certain imaginary pores of the glass. At the first glance these seemed, as he says, "deux suppositions également impossibles, ou du moins très difficiles à concevoir." For very excellent reasons, not difficult for the reader to imagine, the abbé then points out that the latter hypothesis, at all events, is entirely untenable. The question thus became one of the simplest description. If no good reason could be found in support of the seemingly improbable supposition that the experimental results referred to were to be accounted for by a survival of germs, then, as he confessed, he must admit the fact of an independent and germless origin of living things. If, on the other hand, it should appear probable that germs or reproductive particles of living things could survive the influence of such a prolonged immersion in boiling fluids, he would not feel at all bound on the strength of his previous experiments to believe in the independent origin of living matter. This simple issue was fully realized by Spallanzani, and, acting in accordance with the most obvious of scientific principles, he carefully sought for fresh evidence by means of well-directed experiments, in order to guide him toward a conclusion as to whether germs of living things could or could not have resisted the action of boiling water for more than half an hour.

He approached the question in the following manner: "Can one," he says, "find any proof sufficient to banish, or, at all events, to diminish one's natural repugnance to admit that the germs of animalcules of the lowest order have the power of resisting the action of boiling water? In reasoning from the germs or eggs of animals with which we are acquainted, would it be difficult for us to imagine animalcules having this peculiarity? It is true that we are not acquainted with any eggs endowed with such properties. I have already considered this subject in the ninth chapter of my Dissertation. I there show how several kinds of eggs of insects—not to speak of eggs of birds—perish under a heat less than that of boiling water. I have shown also that the seeds of plants are destroyed when they are exposed to the heat of boiling water, and that even those whose outer coat is of the hardest description are not thereby spared." But he goes on to say, as he had only been able hitherto to make his observations on a limited number of eggs and seeds, there was the chance that more extended observations might reveal some capable of resisting this generally destructive influence. He says he had never lost this hope, with regard to seeds more especially, since he had seen a statement by Duhamel to the effect that some grains of wheat had germinated after having been heated in a stove to a temperature above the boiling-point of water.[1] And as there is a considerable resemblance between seeds and eggs, Spallanzani was led to hope that something of the same alleged extraordinary capacity for resisting heat might be possessed by the eggs or germs of such organisms as make their appearance in previously boiled fluids. He was therefore stimulated to undertake fresh observations upon eggs and seeds generally, with the view, on the one hand, of ascertaining the precise temperature which proved fatal to each kind, and, on the other, of finding out whether these eggs or seeds were capable of resisting a greater degree of heat than the several animals or plants to which they belonged.

This latter part of the inquiry was rightly deemed by Spallanzani to be of great importance and capable of affording him much guidance toward the proper interpretation of his other experiments. He had already determined that the lower infusoria themselves are killed at a temperature of 34° Réaumur, or 108½° Fahr.; and now having found that such organisms would appear within closed vessels previously subjected to a temperature of 212° Fahr., owing, as he was inclined to think, to a survival of their germs, Spallanzani was anxious to ascertain whether he could gain sufficient support for this hypothesis—that is, whether the difference in the capacity of resisting heat, imagined to exist in this case between parents and germs, could be justified by the establishment of similar differences in heat-resisting capacity between other parent organisms and their germs.

In carrying out these inquiries, Spallanzani adopted the following method (p. 53): He placed the eggs, seeds, or organisms, in a vessel containing cold water, into the upper strata of which was immersed the bulb of a thermometer. The water was then heated slowly, and when the thermometer indicated that the temperature had been attained, whose effect it was desired to test, the eggs, seeds, or organisms, were at once withdrawn and placed, under suitable conditions, in a separate vessel. The effects of different grades of heat upon the

[1] Heated in all probability in the dry state. But it is well known that seeds and desiccated animals can resist the influence of heat much better in the dried state than when they are thoroughly moistened and then heated, and it is as to the effects of heat upon living matter under the latter conditions with which we are at present concerned. For this reason, therefore, I shall not dwell upon those experiments of Spallanzani, in which he heated seeds in the midst of dry sand—these experiments lie outside the boundaries of our present inquiry.

objects experimented with were thus estimated, and the temperature in successive trials was mostly made to differ from that last employed by 5° R. Operating in this way, and, in the case of eggs or seeds, subsequently taking great care to place those used in the different trials under similar conditions, alike favorable for germination or development, Spallanzani obtained the following results:

Of frogs' eggs only an extremely small number developed after having been simply raised to the temperature of 131° Fahr., while not one developed which had been heated to 145° or upward. Tadpoles produced from similar eggs all perished at 111°, and the same temperature likewise proved fatal to the parent frogs from which the eggs had been derived, as well as to aquatic salamanders and to fish with which experiments were made.

Silk-worms' eggs, and the eggs of the elm-moth (Papillon de l'Orme), developed less and less frequently when successive batches were heated to temperatures approaching 144½°. When they were actually submitted to this heat, all perished, though the highest temperature followed by development is not recorded. Silk-worms themselves, as well as the caterpillars of the elm-moth, were uniformly killed as soon as the water in which they were immersed attained 108½°.

Eggs of the common blow-fly only developed in very small numbers when raised to the temperature of 135°, while all perished at 140°. The larvæ developed from these eggs all died, as those of the silk-worm and elm-moth had done, as soon as the temperature of the water rose to 108½°. Other adult larvæ, of the same species with which experiment was subsequently made, perished at the same heat.

In addition, Spallanzani experimented with some aquatic organisms, though he was unable to discover, and therefore to experiment with, their eggs. Thus leeches perished at 111°, and the Nematoids known as "vinegar-eels" at 113°. Other aquatic worms were killed at 111°, while water-fleas died at 107°.

So far, therefore, Spallanzani's results were most uniform; the different kinds of eggs were killed by mere momentary exposure to a temperature of about 140° Fahr., while the animals to which they were related perished at or about 110°.

The abbé next turned his attention to the power possessed by plants and their seeds of resisting the action of heated water. These observations were conducted in the same manner, though only the roots of the plants were immersed in the water while it was being heated. The plants were afterward carefully replaced in earth. Much care was taken when the seeds were sown to keep the batches distinct from one another, and to place them as much as possible under the influence of similar conditions.

Spallanzani's first experiments were made with the seeds of the chick-pea, lentil, wheat-grass, flax, and clover. The water was heated slowly, and the seeds were taken out as soon as the desired temperature was attained, so that there was only a momentary exposure to the temperatures about to be cited. Of those which had been exposed to 190° Fahr., many did not germinate; still fewer of the seeds that had been exposed to 201° produced young plants, while, of those heated to 212°, not one germinated. After the young plants (developed from seeds heated to lower temperatures) had grown for thirteen days, their capability of resisting heat was tested in the manner described, and with this result. Those whose roots had been momentarily exposed to 156° continued to live after they had been replanted, while those whose roots had been exposed to 167° and upward speedily dried up and perished, although, like the others, they had been replanted in carefully-watered earth.

These were the only complete experiments made by Spallanzani with plants and their seeds; but many other kinds of seeds only, including those of the broad-bean, barley, kidney-bean, maize, vetch, spinach, beet-root, turnip, and mallow, were also exposed to the influence of heat while packed in dry sand. Although this method is less exact and trustworthy, and is one with which we are not now concerned, still it may be stated that only four of the numerous seeds with which experiment was made after this fashion survived their brief exposure in the dry state to the temperature of 212°; all the others failed to germinate.

The abbé's researches, therefore, taught him three things: 1. That eggs can endure a decidedly higher degree of heat than that proving fatal to animals of the kind from which they have been derived; 2. That an analogous difference exists between seeds and plants in respect to their capacity of withstanding the action of heat; and, 3. That seeds and plants can resist higher grades of heat than eggs and animals respectively.

After calling attention to these conclusions, Spallanzani said (p. 64): "Of course I am far from pretending to explain these results; I know the difficulty of the undertaking, and will only venture a few conjectures, at most, letting them go for what they are worth, and leaving every one free to think as he pleases." As his conjectures, however, cannot be much improved upon at the present day, I may as well call the reader's attention to them by briefly pointing out their nature.

At the first glance, the abbé says, the superior power of resisting heat displayed by eggs and seeds, as compared with animals and plants, might be supposed to be due to the latter feeling the effects of heat more rapidly, owing to their being free from those envelopes which inclose the egg or the seed. But the weight of this supposed reason soon disappears, in the case of eggs at all events. Looking to the thinness of their investing membrane, this supposition, as Spallanzani says, "seems very improbable indeed, when we consider how easily and how rapidly fire penetrates so thin a layer of matter." He quickly dismisses, as even more improbable, the notion that the smallness of the germ or egg can act as its safeguard by rendering it less amenable to the influence of heat. Having thus cleared the ground, Spallanzani states what seems to him to be the principal reason of the difference observed. We ought to reflect, he says, upon the difference between the life of an animal in its egg stage and its subsequent life as a developed organism. For, however deficient our knowledge may be upon this subject, we may feel assured that life shows less of the characters of life in the egg than in the organism which is born from it. The life of the egg is "very feeble"—"its life has less of life." And then Spallanzani asks whether the fact of this life of the embryo within the egg being "so small and so feeble"—being "a life which deserves so little the name of life"—may not be the reason that eggs are able to bear the influence of heat better than the developed organisms whose life is more active and complex? He believes this to be the principal reason of the increased power of resisting heat displayed by eggs, and in support of it calls attention to the fact that many animals (as well as plants), when the rate of their vital phenomena is lowered, during winter sleep, are much better able to withstand many injurious external influences than when they are displaying to the full all the manifestations which constitute their "life." Animals, such as frogs and salamanders, for instance, live longer after and resist the effects of injuries better, when they have been incurred during the benumbing cold of winter rather than at periods when these organisms have been full of life and activity.

A similar difference obtains between the degree and complexity of the life of seeds as compared with that of plants, and this difference may in part similarly explain the superior power of resistance to heat shown by seeds—since here, also, among plants, we find that ability to withstand hurtful influences, generally, increases as their life becomes more sluggish. Thus Spallanzani says, "One may say that in winter plants live less fully than at other seasons, and during this period they are also much less liable to perish when they are plucked from the ground or unduly pruned, than if they had been treated in the same manner during summer."

Again, while a difference of the same kind may in part be cited as the cause of the less injurious effects of heat upon seeds and plants as compared with that which it exercises over eggs and animals respectively, Spallanzani points out that this difference between eggs and seeds is only in part due to the fact that the outer coats of most seeds are much harder than those of eggs, since the envelopes of some seeds which are only killed at a temperature near 212° are not harder than the shell of an egg which is nevertheless killed at the much lower temperature of 140° Fahr. This difference is explicable rather, according to Spallanzani, by the fact that the fluids contained within the egg are so much more abundant than those within the seed. In cases of short exposure to heat the animal embryo is thus more easily killed than the vegetable embryo, because its greater moisture causes it rapidly to experience the full effect of the heat, which the seed may possibly escape.[1]

Now, then, for the application of the facts, toward the interpretation of Spallanzani's other experiments in which the lowest organisms appeared in closed flasks whose contents had been exposed to the temperature of boiling water for half an hour. Certainly the germs of such animalcules could not be supposed to have survived such an ordeal if they are to be compared with the eggs of animals, whose death has been brought about by momentary exposure to a temperature far short of the boiling-point. The supposition would, however, seem more possible, if, instead of comparing these germs with the eggs of animals, one regarded them as belonging to the same category as the seeds of plants. Spallanzani frankly admits that they would seem to be more allied to eggs than to seeds, though he attempts to bridge the gap by saying that certain eggs are known (to which these germs may be allied), in some respects resembling seeds. Such eggs "become dry, are preserved in this state, and then develop like seeds after they have been placed in some damp medium. . . . Why, then," he adds, "may not the germs of the lowest kind of animalcules be possessed of a similar nature?" He next (pp. 69–73) adduces various considerations which led him to consider this view as more and more probable, though none of them would be regarded as very relevant by physiologists of the present day. The space at my disposal will not permit of my following him into these details—the reader curious on this subject must therefore consult Spallanzani's work for himself.

The position of things about a century ago, therefore, was this: Not a single living thing, egg, or seed, had been shown to be able to resist, when in the moist state, an exposure to boiling water for a single moment. All naturally moist forms of living matter with which experiment had been made had been shown to be killed by a much lower heat, that is, at a temperature of about 140° Fahr., or less. And, in order to account for the appearance of the lowest animalcules in previously-boiled fluids, Spallanzani assumed—1. That these unknown germs were of the nature of seeds rather than eggs—seeing that they were capable (as he supposed) of undergoing desiccation with impunity,

[1] Spallanzani's argument thus naturally suggests the notion that many of the seeds with which he experimented required a high temperature to kill them, merely on account of their dryness. If the seeds had been well soaked in cold water beforehand, so as to have thoroughly moistened them, might they not have been killed at a much lower temperature—that is, only a little, if at all, above 140° Fahr., or the temperature which proved destructive to the more moist animal germs? Facts which will be subsequently mentioned, since ascertained by Max Schultze and Kühne, would seem to render this very probable, and compel us to regard Spallanzani's experiments with seeds as needing repetition with the modification above suggested. The plants also, like the animals, should have been wholly instead of partially immersed in the heated water.

and that this dryness conferred upon them the greater power of resisting heat which characterized seeds. Nay, further—2. Although no seeds could be shown to be able to resist the influence of boiling water, Spallanzani assumed that these unknown seed-like germs might be able to do so. Thus alone was he able to continue in the panspermatist faith—on the strength of these assumptions only, could he refuse assent to the probability of a germless origin of living matter, more or less after the fashion suggested by Needham and others. It will, therefore, be interesting for us now to consider how far the progress of science tends to confirm or reverse Spallanzani's assumptions.

MENTAL PHYSIOLOGY.

By Dr. J. C. BUCKNILL.

AN important work on the above subject, by a man so eminent and so various in science as Dr. Carpenter, cannot fail to attract the attention and to be worthy of the study of all those whose work in life is to prevent or restore mind from its morbid conditions, and who fully appreciate the necessity of building the edifice of Mental Pathology upon the sure foundations of Physiological Science.

The history of the work before us is told us by the author in his preface. It has grown out of the interesting and suggestive chapters on Psychology, which formed part of the fourth and fifth editions of his "Principles of Human Physiology." It is, however, more than a physiological treatise. It is an attempt to reconcile the facts of science with the reasonings of philosophy, to bridge over the abyss which yawns between materialism and immaterialism, to find some standpoint for free-will, morals, and responsibility, within touching distance of the brain-cells. Quoting from Charles Buxton's "Notes on Thought," the author says:

> "Irresistible, undeniable facts demonstrate that man is not a den wherein two enemies are chained together; but *one being*—that *soul and body are one*—one and indivisible. We had better face this great fact. 'Tis no good to blink it. Our knowledge of physiology has come to a point where the old idea of man's constitution must be thrown aside. To struggle against the overwhelming force of Science, under the notion of shielding Religion, is mere folly."—(*Preface*, p. xiii.)

It is not always certain, when language like the above is used, whether the writer intends to affirm that the body is the soul or the soul is the body, for there is confusion in using two words for one thing, and especially two words which through all the ages of thought have been held to express such opposite meanings. In a work on physiology, however, it is the body and its functions which have to be discussed, and we should have been glad to have found that the body, and the body alone, was the subject of this most learned treatise. Such, however, is very far from being the fact, for, although Dr. Carpenter enters into no ontological discussions, and rarely mentions the soul under its old name, it is present in most pages of his book under the designation of Free-Will. Free-will it is which is the foundation of morals, which renders man responsible for his actions, which gives him the power of forming his own character, which rules and dominates, or at least ought to rule and dominate, all the emotional and intellectual functions of the brain which science shows to be the result of animal chemistry. The autocratic power of the will is the key-note of the whole book, or the red thread which runs through all its pages, as that royal mark does through the ropes and cables of Chatham. Memory is a function of the brain, and so also is judgment, and desire in all its hues, but the will is free, if you will only let it be so; free from the embarrassment of corporeal imperfection, and capable of directing and ruling the senses, the passions, and the reason to all the ends and purposes which good theologians portray as the right aspirations of the soul.

Dr. Carpenter states that—

"According to the view which it has been *the special purpose of this treatise to develop*, the relation of the will to mental is essentially the same as that which it has to bodily action. The measure of its exertion will be the sense of effort which we experience in *intentionally* exciting, directing, or restraining any particular form of mental activity" (p. 138).

The will, therefore, can direct the mind as it can direct the muscles. It can order the attention, and

"Can detach its subjects, which have at the time the *greatest* attractiveness for it, and can forcibly direct it to others from which their attraction would otherwise divert it" (p. 38).

If this be true, the Will exists and is free. But is it true? Can any human being intentionally choose the lesser desire, all things being considered, and all forces outside the so-called will being estimated? This great, greatest perhaps of all questions, is answered by Mr. Mill, and all the determinists, in the negative. Dr. Carpenter takes the opposite view, and founds his mental physiology upon his opinion. He thinks the will is self-determining, and capable of choosing to be influenced by the smaller attraction, and this constitutes its freedom. But if the will exists, and is free, what is it? Certainly not merely the "determinate effort to carry out a purpose previously conceived," as the author in the first instance defines it; for this bare determinate effort is the very idea of it propounded by the most logical necessitarian determinists. It is far more than this.

"We have now, however, to consider a much more obscure question, namely, the *nature* of the *self-determining agency* to which we give the name of Will.

Is it, as some think, the mere resultant of the general (spontaneous or automatic) activity of the mind, and dependent like it upon physical antecedents? Or, is it a power which, being completely independent of these conditions, is capable of acting *against* the preponderance of motives?—as if, when one scale of a beam is declining downward, a hand placed upon the beam from which the other scale is suspended were to cause that lighter scale to go down. Now, that the will *is something essentially different* from the general resultant of the automatic activity of the mind, appears to the writer to be proved, not merely by the evidence of our own consciousness of the possession of a *self-determining power*, but by observation of the striking contrasts which are continually presented in abnormal states of the mind between the automatic activity and the power of volitional control (i. e., in toxic delirium), while the weakening of that power, usually in concurrence with an exaltation of some emotional tendency, is the special characteristic of insanity."

Dr. Carpenter proceeds to show how the will can override reason and judgment, in questions either of intellectual or moral truth, by keeping some considerations out of view and by fixing the attention upon others; so that in this manner the will determines the balance of evidence which commands belief, as it does the balance of evidence which determines conduct. It is, perhaps, superfluous to observe that this self-determining power which rules the senses, guides the opinions, directs the judgment, and controls the conduct of men, which is something essentially different from the general activities of the mind, and is completely independent of physical antecedents, cannot be a physiological, and therefore must be a spiritual power. And this notion agrees with what we have read in other places than Dr. Carpenter's book on Mental Physiology, and where it has caused us less surprise. Granted—we have seen it stated—that perception, memory, emotion, judgment, and all other activities which you more or less successfully demonstrate to be functions of the brain are so in fact, still there is the will. In what ganglion or convolution will you locate that? What influence has the chemistry of the little cells upon that prime motive power? What can change of structure effect there?

It is autocratic, self-dependent, and, excepting in itself and by itself, unchangeable. It is at least a spiritual force with which body has naught to do. It is the heavenly part of man. It is the soul.

The theological bearings of the question will be somewhat out of place in these pages, but it is worth while to remark that the absolute freedom of the will does not fit in with some systems of theology which are tenaciously held by large numbers of Christians.

Let those who think that there can be no morality and no religion, no foundation for human responsibility, and no basis for a moral code, without freedom of the will, read the great work of that grand old Puritan divine, Jonathan Edwards, entitled "A Careful and Strict Enquiry into the Modern Prevailing Notions of that Freedom of the Will which is supposed to be essential to Moral Agency, Virtue and

Vice, Reward and Punishment, Praise and Blame." Romans, ix. 16, "It is not of him that willeth." Edwards, who has been well compared for his philosophic acumen to our own Berkeley, maintains that—

"The decision of most of the points in controversy between Calvinists and Arminians depends upon the determination of this *grand article* concerning the freedom of the will requisite to moral agency."

He argues that God's moral government over mankind is not inconsistent with a determining disposal of all events of every kind throughout the universe.

"Indeed" (he says) "such a universal determining Providence infers some kind of *necessity* of all events—such a necessity as implies an infallible previous fixedness of the futurity of the event; but no other necessity of moral events, or volitions of intelligent agents, is needful in order to this than *moral necessity, which does as much to ascertain the futurity of an event as any other necessity.* As to freedom of will lying in the power of the will to determine itself, there *neither is any such thing*, nor any need of it, in order to virtue, rewards, commands, counsels," etc.

The theology of the most numerous, and, perhaps, the most earnest, sect of Protestant Christians is shown to be utterly adverse to the doctrine of free-will, and it would be equally untrue and uncharitable to deny that the lives of millions of persons guided by these opinions have proved from the Reformation to this hour that the opinion that neither will, thought, nor conduct is free, is consistent with a strict morality.

We have, perhaps, written more than enough for these pages on "the special purpose" of Dr. Carpenter's work, namely, the development of the theory that, although the mental functions generally are automatic, the will is free. The theory, so far as we can ascertain, is not sustained by any facts fit to sustain an argument of such weight. The assumed fact that we are conscious of freedom and power to act in accordance with our moral judgment is revealed in face of the contradiction which it constantly receives, for the sense of restraint said to be felt by one is at least equivalent to the sense of liberty said to be felt by another. It is even more appreciable. A bird may think itself free to fly where it lists, yet, when dropped from a balloon, it falls like a stone. Any captive may think himself free until he get to the bounds, and the freest of us all is still a captive—

"And drags at each remove a lengthening chain."
THE TRAVELLER.

"The tendency of the human free-will is to fly upward," writes our author. "It is by the *assimilation* rather than by the *subjugation* of the human will to the Divine that man is really lifted toward God; and in proportion as this assimilation has been effected does it manifest itself in the life and conduct, so that even the lowliest actions become holy ministrations in a temple consecrated by the felt presence of the Divinity" (p. 428). This, however, is not physiology.

Outside the narrow circle where Dr. Carpenter treads the barren heath of metaphysics, tethered to his theory of free-will, lies the wide and beautiful world of Nature which no one knows better than himself. Naturalist, physiologist, philosopher, philanthropist, there are few men who touch Nature, and human nature, at so many points; and there are very few who can illustrate their knowledge from such rich stores of reading and research.

We are not surprised, therefore, to observe an important journal speaking of Dr. Carpenter's new book as being "as amusing as a novel." Not that novels always are amusing, or that amusement is a proper aim for a scientific work, yet the wealth of illustrative anecdotes scattered through these pages seems to justify the intended compliment of the *Lancet* reviewer. The thought, however, most impressed upon ourselves by Dr. Carpenter's wide acquaintance with men and books, and the use he has made of it in his abundant illustrations of mental phenomena, is that these phenomena are in their very nature so transitory and fluent that they afford most unsatisfactory data for scientific conclusions. Physical facts can be repeated and verified. Even facts of rare occurrence and beyond the control of man do repeat themselves, and can be waited for. The astronomer, or at least astronomers, can wait for the next transit of Venus, or the next appearance of a comet; but who can be expected to wait for the man capable of "repeating correctly a long act of Parliament, or any similar document, after having once read it?" (p. 457); or of that distinguished Scotch lawyer who performed a feat of legal ratiocination while he was asleep, which had baffled the utmost exertion of his waking powers (p. 593). These cases are quoted by the author on the respectable authority of Abercrombie, who recorded them forty years ago, and the time for their repetition has perhaps not yet come full circle round.

Without the opportunity of a verification, men are apt to accept marvelous statements as to mental facts with a degree of indulgent faith which they would never extend to any physical feats or phenomena. No one would accept the statement that a man had run a mile in two minutes, but that a man had performed a prodigious feat of cerebral exertion far surpassing, in comparison with the average powers of man, the excess of power which this would indicate, will gain ready credence, and find record in repetition without end. We should rather have expected that Dr. Carpenter, dealing with the faculties of mind from the scientific point of view, would have had more vividly before him than appears this peculiarity of the evidence on his subject, and that he would have preferred to choose the commoner and more verifiable facts than the curiosities of mental literature; that he would have directed his research rather to the ocean-currents of mind than to the record of occasional floods, transient eddies, and doubtful whirlpools. His method in this respect, we think, is somewhat defective, and method in such a matter is of the very essence of the investigation.

One noteworthy whirlpool of deception and credulity, namely, spiritualism, Dr. Carpenter has investigated here and elsewhere with great care—not, perhaps, so much in reference to the wild turmoil itself, as to the manner in which innocent chips and straws are whirled round on its surface, or engulfed in its depths. He has shown how much and how far persons of a certain constitution may, by automatic action of muscle, nerve, and brain, be the dupes of their own imperfect organization, and the puppets of stronger and more vulgar minds. We could have wished that the peculiarities of extra-automatic people could have been investigated by themselves, and in a strictly scientific manner, and without according the undeserved honor of inquiry to those who travesty the wholesome laws of Nature, convert a fit into a heavenly trance, an hysterical girl into a prophetess, an automatic movement into a communication with the spirits of the dead. We scarcely think that the one grain of truth was worth sifting from all those bushels of chaff and rubbish. Perhaps no one who was not thought to be open to conviction in these matters would have been permitted to look behind the foot-lights, and if Carpenter had spoken sharply and bluntly, as Faraday did of the table-turners, his opportunities for investigation might have been greatly curtailed. As it is, Dr. Carpenter has done rare service in this cause now and aforetime.

Dr. Carpenter states that the number of persons capable of being biologized is "from one in twelve to one in twenty; so that, in a company of fifty or sixty persons, there are pretty sure to be two or three who will prove good biological subjects." We apprehend that a very wide margin must be left for the effects of deception and credulity even in the simple process of biologizing. We never saw a lunatic biologized, and we have seen a hundred experimented upon by professors of the art. In as many school-girls probably a large proportion would be found susceptible, especially if they had been ill supplied with good food and fresh air, and had imbibed an undue amount of sensational poetry and fiction. One lady Dr. Carpenter has himself biologized into so deep a sleep that she could not be awakened by any ordinary means, even by being roughly shaken. "Her slumber appeared likely to be of undefined duration; but it was instantly terminated by the operator's voice calling the lady by her name in a gentle tone." What assurance, however, can the doctor have that this young lady was not playing a trick upon him, or simply indulging a caprice? It is always wise to try the simplest explanation first, and in women the capricious is certainly more common than the biological temperament, even if the author's statistics of the latter be correct.

The warning against these experiments, which are too much the pastime of the idle, the hysterical, and the foolish, is of weighty import:

> "The undue repetition of such experiments, however, and especially their repetition on the same individuals, is to be strongly deprecated; for the state of mind thus induced is essentially a morbid one, and the reiterated suspension of that volitional power over the direction of the thoughts, which is the highest attribute of the human mind, can scarcely do otherwise than tend to its permanent impairment" (p. 565).

The question of "Unconscious Cerebration" or "Latent Mental Modification," which is peculiarly Dr. Carpenter's own, is too important and unsettled to be fully discussed within the brief limits of a review. Dr. Carpenter thinks that his views had been anticipated by Sir William Hamilton, but the passage he quotes from that philosopher scarcely appears to us to detract from the author's priority of thought. Sir W. Hamilton's "mental activities and passivities of which we are unconscious, but which manifest their existence by effects of which we are conscious," are plainly indicated by the sentence which follows as referring to the unknown and the incognizable. We are conscious of the knowable, unconscious of the unknowable.

> "There are many things which we neither know nor can know in themselves, but which manifest their existence indirectly through the medium of their effects. This is the case with the mental modifications in question. They are not in themselves revealed to consciousness, but as certain feats of consciousness; suppose them to exist, and to exert an influence on the mental processes, we are thus constrained to admit as modifications of mind what are not phenomena of consciousness" (p. 518).

Hamilton proceeds to explain that we can only be conscious of a determinate state or mental condition which supposes a transition from some other state: "But as the modification must be present before we have a consciousness of it, we can have no consciousness of its rise or awakening, for this is also the rise or awakening of consciousness."

If all this means any thing, it must mean that we are only conscious of mental states which exist at the time, and that we are unconscious of preceding mental states, or of the transition from preceding to existing states. How Dr. Carpenter can hatch unconscious cerebration out of that egg we cannot imagine.

Neither can we see how John S. Mill can be thought "explicitly to accept the doctrine of unconscious cerebration," seeing that he "considers unconscious mental modification as a contradiction in terms; attributing the phenomena to unrecognized changes in the substance of the brain which he regards as the constant physical attendants of mental modifications."

No doubt there are many brain-changes of which we are not conscious, but mental change, without consciousness, is, according to this very high authority, a contradiction in terms. But all the facts adduced by Dr. Carpenter to prove unconscious cerebration are distinctly mental changes such as, according to Mill, it is a contradiction in terms to designate as unconscious.

These mental changes may be classed almost entirely under two heads: 1. Recollection without effort; and, 2. Apparent increase in the results of thought without further thought.

It may be taken as one of the commonest mental experiences of most men, that a fact, and especially a name, which they endeavor to remember, which escapes from the determinate effort of recollection, often suddenly jumps, as it were, into the recollection without effort, after they have been thinking of other matters. Dr. Carpenter explains this by the theory that the part of the brain engaged in storing up and reproducing past impressions is not the same part of the brain which is engaged in the consciousness of those impressions, or in the consciousness of their reproduction; and that after the seat of consciousness has given up its futile labor, the seat of memory unconsciously continues its activity, and when it has unconsciously brought its work to a successful issue it communicates the result to the seat of consciousness; then, and not before, the fact is consciously remembered. Upon this we must remark that the conscious effort to command the memory, without guide or clew, is generally and singularly unsuccessful in result. The only way to succeed in remembering some forgotten thing is to seek some clew, some thread of ideal association which may lead us to it. The direct bald effort fails, for the simple reason that the attention is fixed upon the effort, and not upon the idea sought. Withdraw the effort, and the attention fixes upon the idea. The memory of the thing was in the brain, must have been there all the time, or it could never again have been remembered. Memory is a latent power, and always unconscious. Recollection is the mental activity which opens the cells of memory to the consciousness and recollection, therefore must always be conscious. That any portion of brain-work is done unconsciously in the act of recollection, is a theory to which we cannot subscribe without far stronger evidence than any which we have yet seen adduced.

The second class of facts adduced to prove that mental work can be performed by the brain without consciousness, are almost as common among men who are in the habit of employing their minds in intricate and difficult subjects. A man thinks on some matter which needs to be considered from various points of mental view, which appears to have bearings on many other subjects which seem to need elucidation from many quarters; he turns all the mental material over and over again until the whole business seems a jumble, and, in confusion and weariness of thought, he puts it aside. He sleeps upon it, and the next day that which overnight was a daub of confused colors, is seen as a bright and clear mental picture. The instances adduced by Dr. Carpenter of this mental phenomenon are varied and exceedingly interesting, but we suppose that no reader of these pages will have any difficulty in referring such experience to himself. But, affirming the facts, will he also agree with the explanation that this power, of seeing old thoughts in a new light, is due to work which the brain has been doing in the mean time, while he was unconscious of its activities? The brain has been doing work, no doubt. It has been replenishing its forces by rest and nutrition. But has it been performing acts of memory and ratiocination? Has it been sifting away the chaff of irrelevant material, and retaining the grain of reason, and the possessor of the brain all the while unconscious of these mental activities? If so, Dr. Carpenter's theory of unconscious cerebration is a new, original, and most important light on the nature of mental activities. But if the power of looking at things anew, of considering arguments afresh, giving irrelevances the chance of being forgotten, and essentials the opportunity of being duly weighed, if this results in the better and clearer understanding of the subject of thought from the simple fact that the mere effort of thought is made under great advantage over the old, then the theory would seem to be unnecessary and superfluous. We think of fishing to-morrow, and pull out fly-books and materials, and are entangled in a medley of feathers, silks, and lines. In the morning we put up our rod, and, with a cast of flies suited to the weather, we seek the stream. Was the mind all night, being unconscious, arranging that which bothered us so in the evening? So with the materials of ratiocination; we begin by collecting from all sides that which may be needful, and the mind becomes perplexed and confused, until the time for decisive thought or action comes, and then we take those things only which are needful.

Dr. Carpenter's theory of unconscious cerebration is in accordance with what we may call his regional physiology of the brain. He places the higher psychical functions in the convolutions of the cerebrum, but the cerebral ganglia or the sensorium is the seat of our consciousness of these functions, as it is that of external sensations, but of that class of "*truly* subjective sensations" which comes to the sensorium, "the result of changes in that cortical layer of the cerebrum which we have reason to regard as the seat of the higher psychical operations." When the psychical operations of the cerebrum have been reflected downward upon the sensorium, they become subjective sensations, and give rise to the formation of an *idea.*

"It is the *sensorium*, not the cerebrum, with which the will is in most direct relation; and in order that this doctrine (which lies at the basis of the whole inquiry as to the relation of the will to motives, and the mode in which it determines our character and actions) may be rightly apprehended, it is necessary here to consider the following physiological question: Whether cerebral changes are in themselves attended with consciousness, or whether we only become conscious of cerebral changes as states of ideation, emotion, etc., through the instrumentality of the sensorium — that is, of that aggregate of sense-ganglia, through the instrumentality of which we become conscious of external sense-impressions, and thus feel sensations?" (p. 109).

"In this point of view the sensorium is the one centre of consciousness for visual impressions on the eye (and by analogy on the other organs of sense), and for ideational or emotional modifications on the cerebrum—that is, in one case for sensations, when we become conscious of sense impressions; and, in the other, for ideas and emotions, when our consciousness has been affected by cerebral changes. According to this view, we no more think or feel with our cerebrum than we see with our eyes; but the *ego* becomes conscious through the same instrumentality of the retinal changes, which are translated (as it were) by the sensorium into visual sensations, and of the cerebral changes, which it translates into ideas and emotions" (p. 111).

It would be impossible to put in clearer language this new doctrine, the psychical and the physiological counterparts of which are thus made to fit so accurately and consistently. The first question, however, which ought to have been entertained is the basement of physiological fact upon which all this imposing edifice has been erected. We are not aware of any, over and above the experiments of Flourens, who showed that birds performed consensual movements, apparently indicating the retention of consciousness, after the cerebrum had been removed down to the optic thalami and the corpora striata. But in complement to these interesting experiments, we have the fact that frogs perform consensual movements which may be taken to *indicate* the retention of consciousness after the spinal cord itself has been divided. The movements of Flourens's pigeons no more prove the retention of consciousness than those of a decapitated frog, which "when acetic acid be applied over the upper and inner part of the thigh, the foot of the same side will wipe it away; but if that foot be cut off, after some ineffectual efforts, and a short period of inaction, the same movement will be made by the foot of the opposite side" (p. 68).

If, under the light of these facts, it be difficult to maintain that the seat of consciousness is not diffused through the central parts of the cerebrum *and* of the spinal cord, the pathological fact that in the human being the optic thalamus or the corpus striatum may be fundamentally changed in consistence and structure by disease, without loss of consciousness, is a barrier against the acceptance of Dr. Carpenter's theory, which, as yet, we are unable to make our way over, under, or through; and, at present, our conclusion is, that unconscious cerebration is an hypothesis all in the air, and unsupported by any foundation of physiological fact.

Whether the activities of the cerebral convolutions are unattended with consciousness until they have been reflected upon the sensorium, is a question which perhaps physiological experiment, or even more likely pathological research, will answer before long. In the mean while we are exceedingly incredulous, and retain our faith in the old opinion that consciousness resides in the cerebral convolutions, and that we are conscious of all mental changes which take place therein.

It is somewhat remarkable that, notwithstanding the large part which consciousness, or want of consciousness, plays in Dr. Carpenter's system, he has nowhere attempted to show wherein it consists or of what it is composed. Certainly it is in great part composed of the perception of sensations coming from without, and, so far, may well be located in the *sensorium commune.* The *cœnæsthesis* also, the common feeling of the organism, enters largely into its composition, and may have its place of recognition in the same cerebral centre. But evidence has yet to be sought that the consciousness of ideas, whether they be intellectual or emotional, has its seat elsewhere than in that part of the brain where these ideas are formed, namely, in the cortical layer of the cerebral convolutions. Dr. Carpenter appears to adopt the metaphysical opinion that consciousness is the perception of the *ego*, and as such is one, simple and indivisible, but the physiological view of consciousness will be that it is highly complex, and compounded variously at every varying moment of perception, ideas, and emotions, some of which obtrude more or less upon the attention, some of which are more or less faint and unrecognized, but which nevertheless exist, and can be found, if the attention be directed to them. The consciousness always is, and must be, highly complex. Even when an intense sensation seems to convert the whole body into one great pain, one sense of torture, there is that sense and the idea of it, and the emotion it causes, and some appreciation of the surroundings faintly recognized; even in *melancholia attonita*, when some one frightful delusion has taken possession of the mind to such an extent that the patient seems to have sunk into the abyss of dementia, he still hears and sees, and has some apprehension of his surroundings, so that even in this case his consciousness is the compound result of very different sensibilities. Some of these are forgotten by the memory, some are lost, but none are forgotten by the mind. As a feather falls not to the earth without drawing the earth to itself, so in psychics, the most feeble and transient sensation, unnoticed and not forgotten, because never really placed in the memory, is still a factor of the mind through all its subsequent existence, and in the history of all mind forever.

A due appreciation of the elements of consciousness, from this point of view, will perhaps lead Dr. Carpenter to admit that unrecognized and unremembered parts of consciousness have still existed among its components, and that, as no motion of matter can exist for a moment without leaving results in modifications of physical universe, so these unrecognized and unremembered parts of consciousness must serve in the chain of mental paternity or genealogy of all succeeding mental states.

The chapter on insanity is excellent, barring the intrusion of the volitional theory. We are glad to obsérve, too, how fully he has adopted our own views of the *emotional* nature of insanity, and of the genesis of intellectual delusions or perverted emotions. These opinions, first advocated by us in the twelfth volume of the *Medico-Chirurgical Review*, in 1853, appear since that time to have been generally adopted by mental physicians, and it is now gratifying to obtain the concurrence of a great physiologist and philosopher.

The modes of disturbed emotion which tend to the production of insanity are not, according to our observations, the various forms of angry passion which are commonly called quick or bad temper, and the author has probably accepted, in too serious a sense, the remark made to him by Dr. Conolly on this point.

> "The writer well remembers, when going with Dr. Conolly through one of the wards on the female side of the lunatic asylum at Hanwell, Dr. Conolly remarked to him, 'It is my belief that *two-thirds* of the women here have come to require restraint through the habitual indulgence of an originally bad temper'" (p. 663).

Conversational remarks of this kind are often made with little intention of their being taken accurately in support of scientific theories. Probably the doctor had just then been vexed with some extraordinary display of female temper, but we think that if questioned he would have admitted that insane women as a class have scarcely worse tempers than other women, and that angry feelings do not constitute the modes of emotion which more frequently lead to the evolution of insanity. Grief and pride, and that compound of hope and fear we call anxiety, these are the modes of emotion which are the frequent groundwork of mental disease.

In conclusion, we can strongly recommend this interesting and erudite work to our readers. If we think the automatism of the mental functions which physiologists are compelled to recognize is opposed adversely to the methods of strict science, by the much-debated and certainly unestablished doctrine of free-will, it must not be forgotten that the author, in his belief in the freedom of the will, has on his side the support of widely-spread opinion, and that it is somewhat unfortunate that his conscientious labors to prove and establish the physiological importance of free-will have fallen in this instance for review into the hands of one who, with Jonathan Edwards, believes that there is no such thing. The scope of the work is far larger than the comments which our space permits us to make would lead our readers to expect. It is replete with information, and remarkable for clearness of statement and of thought. Disagreeing, as we do, with its main purpose, we cannot avoid the expectation and the hope that it will provoke rivalry, and yet it richly deserves, and will no doubt occupy, a place in medical literature, the vacancy of which has been much felt, as a text-book on Mental Physiology.—*Journal of Mental Science.*

RECENT RESEARCHES IN PHOTOGRAPHY.

BY R. MELDOLA.

A SUBSTANTIAL contribution has been recently made to our knowledge of the action of light upon silver salts—a contribution which we cannot but consider as of the highest importance to photography, both as a science and as an art.

In the autumn of last year Dr. Herman Vogel announced,[1] as the result of some experiments that he had been making, that "we are in a position to *render bromide of silver sensitive for any color we choose* —that is to say, to heighten for particular colors the sensibility it was originally endowed with." This discovery is such a decided advance that it will be interesting to trace it from the beginning. Dr. Vogel, in the first instance, found to his astonishment that some dry bromide plates, prepared by Colonel Stuart Wortley in this country, were more sensitive to the green than to the blue portions of the spectrum. This result was so totally opposed to the generally-received notions that the subject was submitted to further examination. In the next experiments, a comparison was instituted between dry bromide plates and the same plates when wet from the bath-solution of silver nitrate. The results showed a decided difference in the behavior of the plates. The sensibility of dry bromide plates appears to extend to a greater extent into the least refrangible end of the spectrum than is the case with wet plates. In Dr. Vogel's plates, which received the spectrum formed by the battery of prisms of a direct vision spectroscope from a ray of sunlight reflected from a heliostat, and passing through a slit 0.25 mm. wide, the photographic impression of the spectrum, when developed by an acid developer, extended, in the case of the dry plates, into the orange, but with wet plates not quite into the yellow. The bromide plates prepared by Vogel, moreover, did not exhibit that increased sensitiveness for the green rays which characterized Colonel Stuart Wortley's plates, and this led the German investigator to conjecture that the latter plates contained some substance which absorbed the green to a greater extent than the blue. To test this conclusion, one of the plates was washed in alcohol-and-water in order to remove the yellow coloring-matter with which the plate was coated, and it was then found to have lost, in accordance with Dr. Vogel's anticipations, its sensitiveness for the green rays. The peculiar action of the Wortley dry plates was thus shown to be due to the coating of coloring-matter, and the next step made by Vogel was to seek some substance which especially absorbed the yellow, and at the same time acted as a sensitizer by fixing the free bromine, liberated by the action

[1] *Poggendorff's Annalen*, vol. cl., p. 453.

of light, upon the silver bromide. Both these ends are fulfilled by the coal-tar color known as coralline. A plate dyed with this substance and exposed to the spectrum, exhibited two maxima of photographic action, one the ordinary maximum in the indigo (near G), and the other almost as strong in the yellow, thus affording complete confirmation of Dr. Vogel's views. Aniline green[1] was next tried. This dye is stated to absorb the red rays, and a corresponding increase of sensitiveness for the red rays was observed, the photograph again presenting two maxima of activity, the one in indigo and one in the red, coinciding in position with the absorption band of the dye. Thus, Dr. Vogel's results may be summarized by saying that a dyed film of silver bromide exhibits maxima of sensitiveness in those regions where the coloring-matter exerts its maximum of absorptive power, but the precise conditions under which these results can be obtained must be considered at present as unknown, since many observers, in repeating the experiments, among others Dr. Van Monckhoven,[2] have failed to obtain other than negative results.

In a communication made to the French Academy on the 27th of last month, however, the well-known physicist, M. Edmond Becquerel, stated that some experiments made at his instigation by M. Deshaies at the Conservatoire des Arts et Métiers had been productive of positive effects, and that some of Dr. Vogel's results with coralline and aniline green had been reproduced. M. Becquerel, however, does not confine himself to bromide films; similar results have been obtained by iodized collodion in which coralline was dissolved. A most remarkable action was observed also in the case of chlorophyll when this substance was used as a tinctorial agent. Although the collodion possessed only a faint-green color from the dissolved chlorophyll, the spectral image was of a much greater length than when plain collodion was used. Under these last circumstances the spectrum extended from the ultra-violet to between G and F, with the usual maximum of action near G, while with chlorophyll the region of strongest action extended from the ultra-violet to the line E in the green, and at the same time a weaker but yet distinct impression extended from E to beyond B in the red, with a strong band between C and D. By a close examination of the spectral image a second band of less intensity could be detected on the least refrangible side of the band between C and D, and other still weaker bands appeared in the green. The most striking confirmation of Vogel's results is to be found in the fact, observed by M. Becquerel, that the band between C and D *corresponds in position with the characteristic band of the absorption spectrum of chlorophyll dissolved in collodion.* The same results were obtained

[1] The green referred to is probably that known as "aldehyde green." The so-called "iodine green," as I have frequently observed, *transmits* a band in the red.

[2] *Photographic Journal*, No. 25, June 20, 1874.

by M. Becquerel with every plate tried and with collodions containing different quantities of chlorophyll.

It must be admitted, then, that a film exerting selective absorption in intimate contact with a sensitive film of silver bromide or iodide affects the latter in those parts of the spectrum where the selective action is taking place. Here, surely, is a wide field for investigation, and one the importance of which will be at once obvious to the physicist. Practically also, when the precise conditions of action are made known, valuable results may be anticipated from the application of this principle to science and to art. Since the year 1842, when M. Becquerel photographed the whole solar spectrum from the extreme violet to the extreme red, and when Dr. J. W. Draper photographed the violet, blue, and extreme red, no successful attempts have been made to imprint the least refrangible end of the spectrum; and this, when we consider the great importance that the study of the solar spectrum has assumed of late years, and the painful or even dangerous character of prolonged eye-observation, is to us a matter of wonder. M. Becquerel's result, it will be remembered, was obtained by a film of silver iodide, first insolated or exposed to diffused light and then to the action of the spectrum. Here, again, is another question—the precise action of *insolation* on sensitive plates—demanding explanation at the hands of the physicist. The practical aspect of Dr. Vogel's discovery need not here be discussed at length. Attention may be called to the well-known difficulty of getting reds or yellows to imprint themselves in portraiture, a difficulty which now bids fair to be overcome.

Then, again, in what we must consider as a higher sphere of practical utility, great advantage to the study of solar physics is likely to accrue. In point of fact, the photographic method of comparing spectra described in a recent communication to the Royal Society now becomes available for the whole extent of the solar spectrum, and our knowledge of the true composition of the sun will be thus in course of time recorded permanently on "that retina which never forgets."

Great results have already been achieved by photography, and greater may be looked for. It must not be forgotten that in this most interesting branch of chemical physics we are in a period either of provisional hypothesis, or, worse still, of no hypothesis at all, so that valuable additions to our knowledge of physical and chemical laws should be forthcoming. The changes wrought by a beam of light on sensitive surfaces are sometimes physical and sometimes chemical. We may appropriately recall here the fact that mechanical pressure upon a sensitized surface of a silver salt acts in the same manner as a ray of light, giving a dark stain under the action of reducing agents. The experiment of Grove also, in which an electric current is set up by the incidence of a beam of light upon a prepared Daguerreotype plate, should not be forgotten. The equivalence between light and the other form of force has not yet been established, and it may not be going too far to conjecture that thermodynamics may possibly in the future have to appeal to the action of light upon a photographic plate. In the mean time we look forward to the promised continuation of Dr. Vogel's researches with no little hope.—*Nature.*

THE ELECTRIC LIGHT FOR STEAMSHIPS.

BY JOHN TROWBRIDGE,
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THE employment of the electric light for general purposes of illumination has not, hitherto, been successful. The difficulty of maintaining it constant, and the expense attending its use, have prevented its employment. In the old method of producing the light by a great number of cells, the chief difficulties arose in keeping the strength of the current constant, and in regulating the distance of the carbon-points between which the light was produced. Certain forms of the Daniell cell, notably that constructed by Sir William Thomson ("Jenkins's Electricity," p. 223), give a sensibly constant current for an indefinite period, if watched with great care. The solutions of the cells, however, need to be carefully removed from time to time. The distance of the carbon-points also can be regulated by various contrivances, which do the work required of them in an admirable manner. Still, chemical action cannot be looked to as an economical and constant source of the electric light.

The remarkable improvements in magneto-electric engines have led to another source of the electric light, and seem to afford a better solution of the problem of its economical use. The principle which underlies all magneto-electric engines can be briefly stated thus: The movement of an electro-magnet in the neighborhood of a stationary magnet, which may also be an electro-magnet, is sufficient to induce a current in the coil of the first electro-magnet, and this current can be exalted in strength almost indefinitely by its proper direction, and by the rapidity of the mechanical movement. The most noted engines are those of Siemen and Hulske, Wild, Ladd, and the Gramme machine. Some idea of the power of these engines can be gained from the following statement in regard to a Wild machine, of a size intended to be used for the production of the electric light for light-houses: "When worked with a power of three horses, it will consume carbon-sticks three-eighths of an inch square, and evolve a light of surpassing brilliancy. With a machine that consumes carbons half an inch square, a light of such intensity is got, that, when put on a lofty building, it casts shadows from the flames of the street-lamps a quarter of a mile distant upon the neighboring walls. The same light, at two feet from the reflector, darkened ordinary sensitized photographic paper as much in twenty seconds as the direct rays of the sun at noon on a clear day in March in one minute" (Ferguson's "Electricity"). With a ten-inch quantity armature, Mr. Wild succeeded in melting an iron rod fifteen inches long and one-quarter inch thick. The entire machine by which this was accomplished was under five feet in length and height, was only twenty inches wide, and weighed a ton and a half. The Ladd engine dispenses with the use of permanent steel magnets, and is a more compact form of the machine than Wild's. The Gramme machine returns again to the use of powerful steel magnets, between the poles of which revolves a ring-shaped electro-magnet. The problem of producing the best machine for the production of electricity by mechanical power is not yet solved. The machines now before the public will doubtless be very much improved. At present, however, the means to attain the sought-for ends seem to be limited. There are not many combinations which can be made. A field of magnetic force being given, the question arises, What is the most economical means of cutting the greatest number of lines of force of the greatest intensity in the unit of time? With the most improved forms of the magneto-electric machine, we are, however, in a condition to produce an electric light of a reasonable degree of constancy and cheapness. If it is a desideratum that steamships should be provided with more powerful lights than those now in use, the electric light is the one to which attention is naturally directed. The first points to be considered are in relation to its cost, its constancy, and readiness of adjustment, and its efficiency in penetrating fogs. The light-house service of Great Britain and France affords the only experience on these points.

The electric light has been tried by Great Britain at Dungeness, and by the French Government at La Hève. The source of the light in both instances was a magneto-electric machine. A force of one and a quarter horse-power was required to drive the British machine, and one and a half the French. The descriptions of these machines show that they were extremely bulky, compared with the more improved forms, like Ladd's and the Gramme machine. The observations on the lights at La Hève are especially interesting, because they afforded a means of comparison between the fog-penetrating power of the electric light and the ordinary oil-light of light-houses. There were two light-houses at La Hève, one of which was provided with an electric light, and the other with an oil-light. The electric light was equivalent to 3,500 Carcel-burners. The oil-light had an intensity of 630 Carcel-burners.

"In foggy weather, in the hundred times of observation, the electric light was seen twice as often as the oil-light, or more. When the intensity of the electric light, compared with that of the oil-lamp with which it was measured, is considered, this is not a favorable exhibit. An advantage, nevertheless, which the electric light very distinctly possessed over the other, was in its creating a kind of glow in the fog, by which mariners were enabled to recognize the position of the capes even when both lights were invisible. Experiments were made with the view of ascertaining, with some approach to accuracy, the relative fog-penetrating power of the two descriptions of light produced by electricity and by ordinary combustion, when the photometric intensities are equal; and also the excess of intensity which must be given to the former light, in order that its power in this respect may be equal to that of a lamp fed by oil. In these experiments it was attempted to imitate, as nearly as possible, the absorbent effect of fogs, by interposing glasses of different colors—red, orange, yellow, etc.—before each of the lights successively. The conclusion which these experiments seem to justify is, that, whenever an electric light exceeds in intensity a light produced by a lamp two and a half times, it will penetrate, at least as well as the latter, the fogs most unfavorable to the transmission of the rays. And, as a fact, in whatever state of the weather, the electric light at La Hève has always had the largest range of visibility" ("Reports of the United States Commissioners to the Paris Exposition, 1867," vol. iii.).

M. Becquerel, in an article on electrical apparatus exhibited in the Exposition of 1862, enters into a calculation of the cost of the electric light, compared with other methods of illumination. His estimates are based upon a light produced by a magneto-electric engine, driven by an engine of two horse-power, which light he calculated was equivalent to that produced by 700 stearine-candles. He compares the light thus obtained with that obtained of equal intensity from the galvanic battery—from coal-gas, oil of colza, tallow, stearine, and wax. "The price of gas taken was $\frac{30}{100}$ of a franc per cubic metre—equivalent to 17 cents per 100 cubic feet; oil of colza, $1.28 per gallon; tallow, in the form of candles, 16 cents; stearine, 36 cents; and wax, 52 cents per pound." The cost of the electric light he assumes to be only that of the combustibles required to run the engine. From these data he deduces the following values:

A light equal to that of 700 stearine-candles will cost per hour:

1	produced	by the	Machine	2 to 4 cents.
2	"	"	Galvanic battery	38 to 94 cents.
3	"	"	Coal-gas	62 cents.
4	"	"	Kerosene	73 cents.
5	"	"	Pure oil of Colza	$1.14
6	"	"	Tallow-candles	2.37
7	"	"	Stearine	5.00
8	"	"	Wax	6.10

"In point of cheapness there would seem to be no comparison between the electric light and that produced by even the least costly of the materials ordinarily employed for purposes of illumination. Actual experiment, however, in the use of these machines in French light-houses, has shown that these figures require important modifications" ("United States Commissioner's Report to the Paris Exposition, 1867," vol. iii., p. 421).

The French Commission, in view of the experience gained by the establishment of the light at La Hève, did not advocate the extension of the use of the electric light to light-house illumination in general. The expense of maintaining the electric light at Dungeness, irrespective of the original cost, was estimated to be £758 18*s.* 9*d.* per annum. M. Becquerel evidently did not take into account in his calculation the original cost of the machine; and the expense of the light at Dungeness would be modified by the greater cheapness of the more improved forms of engines.

For several years it has been rumored that various steamships were to be furnished with the electric light instead of the old well-established masthead-light. No trial has yet been made. The cost of the apparatus, together with the imperfect means hitherto devised for maintaining the light constant, has deterred, apparently, the owners of steamship lines from making a change in this direction. When we reflect that the best masthead-light now in use can be seen only from four to five miles—by some authorities stated from three to four—and in a fog at night is practically not visible more than the length of a steamship ahead, it is not surprising that the general public look earnestly for a change for the better. The experience which the use of the electric light in light-houses has given us is, on the whole, favorable to an extension of the use of the light to steamships. There is no question of the superiority of the electric light over other powerful lights available for steamships, when the great intensity of the light and the compactness of the necessary apparatus are considered. The following is an estimate of the probable cost of fitting steamships with an electric light, together with its maintenance:

FIRST COST.

Machine	$1,500
Regulators and attachments	300
Small engine to run the machine	600
Total	$2,400

MAINTENANCE.

Interest on capital, at ten per cent	$240
Salary of electrical engineer	600
Carbons (or other incandescent material), repairs, etc	300
Total	$1,140

Suppose that the vessel made 18 trips during the year, of 12 days each (216 days), suppose that the electric light was used 10 hours each night (2,160 hours), giving about 53 cents as the cost per hour, the additional fuel required, estimated at three cents per hour, would bring the estimate up to 56 cents per hour. It is probable that a suitable magneto-electric engine would cost less than our estimate. The engine of Mr. M. G. Farmer, of Boston, the celebrated electrician, bids fair to play an important part in applications of the electric light. The engines of the ship could doubtless run by suitable attachments the magneto-electric engine, and our estimate of one attendant would doubtless prove sufficient, with the aid of the ordinary ship-watch.

When one reflects upon the number of steamships crossing the Atlantic, and the increasing danger of collision, with the feeble lights now in use, one is forced to wonder at the want of agitation of the subject. It is safe to affirm that, had the Ville du Havre been provided with more powerful lights, the fatal collision would not have happened. The loss which the steamship company suffered by this collision would have furnished their entire fleet with the apparatus for producing the electric light. With a careful watch, a light which can be seen three miles on a clear night would doubtless prove sufficient. The fog-whistle, with an equally careful watch, can also be made efficient to prevent collisions. But a careful watch cannot always be had; there are many temptations to be careless. Drowsiness, in chilly weather, creeps upon even a conscientious lookout, and a powerful masthead-light would supplement human fallibility.

ARE ANIMALS AUTOMATONS?[1]

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

I SHALL go no further back than the seventeenth century, and the observations which I shall have to offer you will be confined almost entirely to the biological science of the time between the middle of the seventeenth and middle of the eighteenth centuries. I propose to show what great ideas in biological science took their origin at that time, in what manner the speculations then originated have been developed, and in what relation they stand to what is now understood to be the body of scientific biological truth. The middle of the seventeenth century is one of the great epochs of biological science. It was at that time that an idea arose that vital phenomena, like all other phenomena of the physical world, are capable of mechanical explanation, that they are reducible to law and order, and that the study of biology is an application of the great science of physics and chemistry. Harvey was the first clearly to explain the mechanism of the

[1] An address delivered before the British Association at Belfast, August 25th.

circulation of the blood, and by that remarkable discovery of his he laid the foundation of a scientific theory of the larger part of the processes of living beings—those processes, in fact, which we now call processes of sustentation—and by his studies of development he first laid the foundation of a scientific knowledge of reproduction. But, besides these great powers of living beings, there remains another class of functions—those of the nervous system—with which Harvey did not grapple. It was, indeed, left for a contemporary of his, Réné Descartes, to play a part in relation to the phenomena of the nervous system which is precisely equal in value to that Harvey played in regard to the circulation. You must recollect that this man Descartes was not merely, as some had been, a happy speculator. He was a working anatomist and physiologist, conversant with all the anatomical and physiological law of his time. A most characteristic anecdote of him, and one which should ever put to silence those shallow talkers who speak of Descartes as an hypothetical and speculative philosopher, is, that a friend once calling upon him in Holland begged to be shown his library. Descartes led him into a sort of shed, and, drawing aside a curtain, displayed a dissecting-room full of the bodies of animals in course of dissection, and said, "There is my library."

The matters of which we shall treat are such as to require no extensive knowledge of anatomy. I need only premise that what we call the nervous system in one of the higher animals consists of a central apparatus, composed of the brain, which is lodged in the skull, and of a cord proceeding from it, which is termed the spinal marrow, and which is lodged in the vertebral column or spine, and that then from these soft white masses—for such they are—there proceed cords which are termed nerves, some of which nerves end in the muscle, while others end in the organs of sensation. The first proposition that you find definitely and clearly stated by Descartes is the view that the brain is the organ of sensation, of thought, and of emotion—using the word "organ" in this sense, that certain changes which take place in the matter of the brain are the essential antecedents of those states of consciousness which we term sensation, thought, and emotion. If your friend disagrees with your opinion, runs amuck against any of your pet prejudices, you say, "Ah! poor fellow, he is a little touched here," by which you mean that his brain is not doing its business properly—that he is not thinking properly—thereby implying that his brain is some way affected. It remained down to the time of Bichat a question whether the passions were or were not located in the abdominal viscera. In the second place, Descartes lays down the proposition that all the movements of the animal bodies are effected by the change of form of a certain part of the matter of their bodies, to which he applies the general term of muscle. That is a proposition which is now placed beyond all doubt whatever. If I move my arm, that movement is due to the change of this mass in front called the biceps muscle; it is shortened till it becomes thicker. If I move any of my limbs, the reason is the same. As I now speak to you, the different tones of my voice are due to the exquisitely accurate adjustments and adjusted contractions of a multitude of such particles of flesh; and there is no considerable and visible movement of the animal body which is not, as Descartes says, resolvable into these changes in the form of matter termed muscle. But Descartes went further, and he stated that in the normal and ordinary condition of things these changes in the form of muscle in the living body only occur under certain conditions; and the essential condition of the change was, says Descartes, the motion of the matter contained within the nerves, which go from the central apparatus to the muscle. Descartes gave this moving material a particular name—the animal spirits. Nowadays we should not say that the animal spirits existed, but we should say that a molecular change takes place in the nerve, and that that molecular change is propagated at a certain velocity which has been measured from the central apparatus to the muscle. Modern physiology has measured the rate of the change to which I have referred.

Next, Descartes says that, under ordinary circumstances, this change in the contents of a nerve, which gives rise to the contraction of a muscle, is produced by a change in the central nervous apparatus, as, for example, the brain. We say at the present time exactly the same thing. Descartes said that the animal spirits were stored up in the brain, and flowed out from the motor nerve. We say that a molecular change takes place in the brain that is propagated along the motor nerve. Further, Descartes stated that the sensory organs which give rise to our feelings gave rise to a change in the sensory nerves, to a flow of animal spirits along those nerves, which flow was propagated to the brain. If I look at this candle before us, the light falling on the retina of my eye gives rise to an affection of the optic nerve, which affection Descartes described as a flow of the animal spirits to the brain; but the fundamental idea is the same. In all our notions of the operations of nerve we are building upon Descartes's foundation. He says that, when a body which is competent to produce a sensation touches the sensory organs, what happens is the production of a mode of motion of the sensory nerves. That mode of motion is propagated to the brain. That which takes place in the brain is still nothing but a mode of motion. But, in addition to this mode of motion, there is, as everybody can find by experiment for himself, something else which can in no way be compared to motion, which is utterly unlike it, and which is that state of consciousness which we call a sensation. Descartes insists over and over again upon this total disparity between the agent which excites the state of consciousness and the state of consciousness itself. He tells us that our sensations are not pictures of external things, but that they are symbols or signs of them; and in doing that he made one of the greatest possible revolutions, not only in physiology but in philosophy. Till his time it was the notion that visible bodies, for example, gave from themselves a kind of film which entered the eye and so went to the brain, *species intellectuales* as they were called, and thus the mind received an actual copy or picture of things which were given off from it. In laying down that proposition upon what I imagine to be a perfectly irrefragable basis, Descartes laid the foundation of that form of philosophy which is termed idealism, which was subsequently expanded to its uttermost by Berkeley, and has taken all sorts of shapes since.

But Descartes noticed not only that under certain conditions an impulse made by the sensory organ may give rise to a sensation, but that under certain other conditions it may give rise to motion, and that this motion may be effected without sensation, and not only without volition, but even contrary to it. I know in no modern treatise of a more clear and precise statement than this of what we understand by the automatic action of the brain. And what is very remarkable is, that, in speaking of these movements which arise by a sensation being as it were reflected from the central apparatus into a limb—as, for example, when one's finger is pricked and the arm is suddenly drawn up, the motion of the sensory nerve travels to the spine and is again reflected down to the muscles of the arm—Descartes uses the very phrase that, we at this present time employ. And the last great service to the physiology of the nervous system which I have to mention as rendered by Descartes was this, that he first, so far as I know, sketched out the physical theory of memory. What he tells you in substance is this, that when a sensation takes place, the animal spirits travel up the sensory nerve, pass to the appropriate part of the brain, and there, as it were, find their way through the pores of the substance of the brain. And he says that, when the particles of the brain have themselves been shoved aside a little by the single passage of the animal spirits, the passage is made easier in the same direction for any subsequent flow of animal spirits, and that the repetition of this action makes it easier still, until at length it becomes very easy for the animal spirits to move these particular particles of the brain, the motion of which gives rise to the appropriate sensation, until at length the passage is so easy that almost any thing, especially an associated flow which may be set going, allows the animal spirits to flow into these already open pores more easily than they would flow in any other direction; and in this way a flow of the animal spirits recalls the image—the impression made by a former sensory act. That, again, is essentially in substance at one with all our present physical theories of memory. In one respect Descartes proceeded further than any of his contemporaries, and has been followed by very few of his successors in later days. Descartes reasoned thus: "I can account for many such actions, many reflex actions taking place without the intervention of consciousness, and even in opposition to the will." So far these occur, as, for example, when a man in falling mechanically puts out his hands to save himself. "In these cases," Descartes said, "I have clear evidence that the nervous system acts mechanically without the intervention of consciousness, and without the intervention of the will, it may be in opposition to it." Why, then, may I not extend this idea further? As actions of a certain amount of complexity are brought about in this way, why may not actions of still greater complexity be so produced? Why, in fact, may it not be that the whole of man's physical actions are mechanical, his mind living apart, like one of the gods of Epicurus, but unlike them occasionally, interfering by means of his volition?

And it so happened that Descartes was led by some of his speculations to believe that beasts had no soul, and consequently, according to his notion, could have no true mental operations, and no consciousness; and thus, his two ideas harmonizing together, he developed that famous hypothesis of the automatism of brutes, which is the main subject of my present discourse. What Descartes meant by this was that animals are absolutely machines, as if they were mills or barrel-organs; that they have no feelings; that a dog does not hear, and does not smell, but that the impression which thus gave rise to those states of consciousness in the dog gave rise by a mechanical reflex process, to actions which correspond to those which we perform when we do smell, and do taste, and do see. Suppose an experiment. Suppose that all that is taken away of the brain of a frog is what we call the hemisphere, the most anterior part of the brain. If that operation is properly performed, very quickly and very skillfully, the frog may be kept in a state of full bodily vigor for months, or it may be for years; but it will sit forever in the same spot. It sees nothing; it hears nothing. It will starve sooner than feed itself, although, if food is put into its mouth, it swallows it. On irritation, it jumps or walks; if thrown into the water, it swims. But the most remarkable thing that it does is this—you put it in the flat of your hand, it sits there, crouched, perfectly quiet, and would sit there forever. Then if you incline your hand, doing it very gently and slowly, so that the frog would naturally tend to slip off, you feel the creature's fore-paws getting a little slowly on to the edge of your hand until he can just hold himself there, so that he does not fall; then, if you turn your hand, he mounts up with great care and deliberation, putting one leg in front and then another, until he balances himself with perfect precision upon the edge of your hand; then if you turn your hand over, he goes through the opposite set of operations until he comes to sit in perfect security upon the back of your hand. The doing of all this requires a delicacy of coördination and an adjustment of the muscular apparatus of the body which are only comparable to those of a rope-dancer among ourselves; in truth, a frog is an animal very poorly constructed for rope-dancing, and on the whole we may give him rather more credit than we should to a human dancer.

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. And what is still more remarkable is this, that, if you put him 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 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.

I need not say that since those days of commencing anatomical science when criminals were handed over to the doctors, we cannot make experiments on human beings, but sometimes they are made for us, and made in a very remarkable manner. That operation called war is a great series of physiological experiments, and sometimes it happens that these physiological experiments bear very remarkable fruit. A French soldier, a sergeant, was wounded at the battle of Bareilles. The man was shot in what we call the left parietal bone. The bullet, I presume, glanced off, but it fractured the bone. He had enough vigor left to send his bayonet through the Prussian that shot him. Then he wandered a few hundred yards out of the village, where he was picked up and taken to the hospital, where he remained some time. When he came to himself, as usual in such cases of injury, he was paralyzed on the opposite side of the body, that is to say, the right arm and the right leg were completely paralyzed. That state of things lasted, I think, the better part of two years, but sooner or later he recovered from it, and now he is able to walk about with activity, and only by careful measurement can any difference between the two sides of his body be ascertained. At present this man lives two lives, a normal life and an abnormal life. In his normal life he is perfectly well, cheerful, and a capital hospital attendant, does all his work well, and is a respectable, well-conducted man. That normal life lasts for about seven-and-twenty days, or thereabouts, out of every month; but for a day or two in each month—generally at intervals of about that time—he passes into another life, suddenly, and without warning or intimation. In this life he is still active, goes about just as usual, and is to all appearance just the same man as before; goes to bed and undresses himself, gets up, makes his cigarette and smokes it, and eats and drinks. But in this condition he neither sees, nor hears, nor tastes, nor smells, nor is he conscious of any thing whatever, and has only one sense-organ in a state of activity—viz., that of touch, which is exceedingly delicate. If you put an obstacle in his way he knocks against it, feels it, and goes to the one side. If you push him in any direction he goes straight on, illustrating, as well as he can, the first law of motion. You see I have said he makes his cigarettes, but you may make his tobacco of shavings or of any thing else you like, and still he will go on making his cigarettes as usual. His action is purely mechanical. As I said, he feeds voraciously, but whether you give him aloes or asafœtida, or the nicest thing possible, it is all the same to him.

The man is in a condition absolutely parallel to that of the frog, and no doubt, when he is in this condition, the functions of his cerebral hemispheres are at any rate largely annihilated. He is very nearly —I don't say wholly, but very nearly—in the condition of an animal in which the cerebral hemispheres are not entirely extirpated, but very largely damaged. And his state is wonderfully interesting to me, for it bears on the phenomena of mesmerism, of which I saw a good deal when I was a young man. In this state he is capable of performing all sorts of actions on mere suggestion—as, for example, he dropped his cane, and a person near him put it into his hand, and the feeling of the end of the cane evidently produced in him those molecular changes of the brain which, had he possessed consciousness, would have given rise to the idea of his rifle; for he threw himself on his face, began feeling about for his cartouche, went through the motions of touching his gun, and shouted out to an imaginary comrade, "Here they are, a score of them; but we will give a good account of them." This paper to which I refer is full of the most remarkable examples of this kind, and what is the most remarkable fact of all is, the modifications which this injury has made in the man's moral nature. In his normal life he is one of the most upright and honest of men. In his abnormal state, however, he is an inveterate thief. He will steal every thing he can lay his hands upon, and, if he cannot steal any thing else, he will steal his own things and hide them away. Now, if Descartes had had this fact before him, need I tell you that his theory of animal automatism would have been enormously strengthened? He would have said: "Here, I show you a case of a man performing actions evidently more complicated and mostly more rational than any of the ordinary operations of animals; and yet you have positive proof that these actions are merely mechanical. What, then, have you to urge against my doctrine that the whole animal world is in that condition, and that—to use the very correct words of Father Malebranche—'Thus in dogs, cats, and other animals, there is neither intelligence nor spiritual soul as we understand the matter commonly; they eat without pleasure—they cry without pain—they grow without knowing it—they desire nothing, they know nothing; and, if they act with dexterity and in a manner which indicates intelligence, it is because God, having made them with the intention of preserving them, has constructed their bodies in such a manner that they escape organically, without knowing it, every thing which could injure them, and which they seemed to fear.'"

But I must say for myself—looking at the matter on the ground of analogy—taking into account that great doctrine of continuity which forbids one to suppose that any natural phenomenon can come into existence suddenly and without some precedent, gradual modification tending toward it—taking that great doctrine into account (and every thing we know of science tends to confirm it), and taking into account on the other hand the incontrovertible fact that the lower animals which possess brains at all possess, at any rate, in rudiments a part of the brain, which we have every reason to believe is the organ of consciousness in ourselves, then it seems vastly more probable that the lower animals, although they may not possess that sort of consciousness which we have ourselves, yet have it in a form proportional to the comparative development of the organ of that consciousness, and foreshadow more or less dimly those feelings which we possess ourselves. I think that is, probably, the most rational conclusion that can be come to. It has this advantage, that it relieves us of the very terrible consequences of making any mistake on this subject. I must confess that, looking at that terrible struggle for existence which is everywhere going on in the animal world, and considering the frightful quantity of pain which must be given and received in every part of the animal world, I say that is a consideration which would induce me wholly to adopt the view of Descartes. Yet I think it on the whole much better to err on the right side, and not to concur with Descartes on this point. But let me point out to you that, although we may come to the conclusion that Descartes was wrong in supposing that animals are insensible machines, it does not in the slightest degree follow that they are not sensitive and conscious automata; in fact, that is the view which is more or less clearly in the minds of every one of us. 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 do act mechanically, and that their different states of consciousness, their sensations, their thoughts (if they have them), their volitions (if they have them), are the products and consequences of the mechanical arrangements. I must confess that this popular view is to my mind the only one which can be scientifically adopted. We are bound by every thing we know of the operations of the nervous system to believe that, when a certain molecular change is brought about in the central part of the nervous system, that change, in some way utterly unknown to us, causes that state of consciousness that we term a sensation. It is not to be doubted that the impression excited by those motions which give rise to sensation leaves in the brain molecular changes which answer to what Haller called "*vestigia rerum*," and which that great thinker David Hartley termed "vibratiuncles," which we might term sensigenous molecular, and which constitute the physical foundation of memory. Those same changes gave rise naturally to conditions of pleasure and pain, and to those emotions which in ourselves we call volition. I have no doubt that is the relation between the physical processes of the animal and his mental processes. In each case it follows inevitably that these states of consciousness can have no sort of relation of causation to the motions of the muscles of the body. The volition of animals will be simply states of emotion which precede their actions. The only conclusion, then, at which there seems any good ground for arriving is, that animals are machines, but that they are conscious machines.

I might, with propriety, consider what I have now said, as the conclusion of the observations which I have to offer concerning animal automatism. So far as I know, the problem which we have hitherto been discussing is an entirely open one. I do not know that there is any reason on the part of any person, whatever his opinions may be, that can prevent him, if he be so inclined, from accepting the doctrine which I have just now put before you. So far as we know, animals are conscious automata. That doctrine is perfectly consistent with any view we may choose to take on a very curious subject of speculation—whether animals possess souls or not, and whether, if they possess souls, those souls are immortal or not. The doctrine to which I have referred is not inconsistent with the perfectly strict and literal adherence to the Scripture text concerning the beast that perisheth, nor, on the other hand, so far as I know, does it prevent any one from entertaining the amiable convictions ascribed by Pope to his untutored savage, that, when he passed to the realms of the blessed, his faithful dog should bear him company. In fact, all these accessory questions to which I have referred involve problems which cannot be discussed by physical science as such, as they lie, not within the scope of physical science, but come within the scope of that great mother of all science, Philosophy. Before any direct answer can be given upon any of these questions, we must hear what Philosophy has to say for and against the views that may be held. I have now laid these facts before you. I do not doubt that that fate will befall me which has befallen better men, and I shall have to bear in patience the reiterated assertion that doctrines such as I have put before you have very evil tendencies. I should not wonder if you were told that my intention in bringing this subject before you is to lead you to apply the doctrine I have stated to man as well as brutes, and it will then certainly be further stated that the logical tendency of such a doctrine is Fatalism, Materialism, and Atheism.

Now, let me ask you to listen to another product of that long experience to which I have referred. The logical consequences are very important; but in the course of my experience I have found that they were the scarecrows of fools and the beacons of wise men. Logical consequences can take care of themselves. The only question for any man to ask is this: "Is this true or is it false?" No other question can possibly be taken into consideration until that one is settled. Undoubtedly I do hold that the view I have taken ot the relations between the physical and mental faculties of brutes applies in its fullness and entirety to man; and, if it was true that the logical consequences of that belief must land me in all these terrible things, I do not hesitate in allowing myself to be so landed. I should conceive that, if I refused, I should have done the greatest and most abominable violence to every thing which is deepest in my moral nature. But now I beg leave to say that, in my conviction, there is no such logical connection as is pretended between the doctrine I accept and the consequences which people profess to draw from it. Many years ago I had occasion, in dealing with the philosophy of Descartes, and some other matters, to state my conviction pretty fully on those subjects, and, although I know by experience how futile it is to endeavor to escape from those nicknames which many people mistake for argument, yet, if those who care to investigate these matters in a spirit of candor and justice will look into those writings of mine; they will see my reasons for not imagining that such conclusions can be drawn from such premises. To those who do not look into these matters with candor and with a desire to know the truth I have nothing whatever to say, except to warn them on their own behalf what they do; for assuredly, if, for preaching such doctrine as I have preached to you to-night, I am cited before the bar of public opinion, I shall not stand there alone. On my one hand I shall have, among theologians, St. Augustine, John Calvin, and a man whose name should be well known to the Presbyterians of Ulster—Jonathan Edwards—unless, indeed, it be the fashion to neglect the study of the great masters of divinity, as many other great studies are neglected nowadays. I should have upon my other hand, among the philosophers, Leibnitz; I should have Père Malebranche, who saw all things in God; I should have David Hartley, the theologian as well as philosopher; I should have Charles Bonnet, the eminent naturalist, and one of the most zealous defenders Christianity has ever had. I think I should have, within easy reach at any rate, John Locke. Certainly the school of Descartes would be there, if not their master; and I am inclined to think, in due justice, a citation would have to be served upon Emmanuel Kant himself. In such society it may be better to be a prisoner than a judge; but I would ask those who are likely to be influenced by the din and clamor which are raised about these questions whether they are more likely to be right in assuming that those great men I have mentioned—the fathers of the Church and the fathers of philosophy—knew what they were about, or that the pigmies who raise this din know better than they did what they meant. It is not necessary for any man to occupy himself with problems of this kind unless he so choose. Life is full enough, filled amply to the brim, by the performance of its ordinary duties; but let me warn you, let me beg you to believe that if a man elect to give a judgment upon these great questions; still more, if he assume to himself the responsibility of attaching praise or blame to his fellow-men for the judgments which they may venture to express, I say that, unless he would commit a sin more grievous than most of the breaches of the Decalogue, let him avoid a lazy reliance upon the information that is gathered by prejudice and filtered through passion. Let him go to these great sources that are open to him as to every one, and to no man more open than to an Englishman; let him go back to the facts of Nature, and to the thoughts of those wise men who for generations past have been the interpreters of Nature.

TYNDALL'S RELATION TO POPULAR SCIENCE.

By Professor HELMHOLTZ.[1]

THE awakening desire for scientific instruction, ever finding new expression among the educated classes of all European countries, we must consider not merely as a striving after new forms of amusement, or a mere empty and barren curiosity; it is rather a well-justified intellectual necessity, and is in close connection with the most important springs of mental development in these times. The natural sciences have become a powerful influence in the formation of the social, industrial, and political life of civilized nations, not only from the fact that the great forces of Nature have been subordinated to the aims of man, and have supplied him with a host of new means to attain them; though this mode of their action is sufficiently important that the statesman, the historian, and the philosopher, as well as the manufacturer and the merchant, cannot pass without participation in, at least, the practical results; but because there is another form of their action which goes much deeper and further, though it is, perhaps, more slow in manifesting itself; I mean their influence in the direction of the intellectual progress of humanity. It has often been said, and even brought as a charge against the natural sciences, that, through them, a schism (*Zwiespalt*), formerly unknown, has been introduced into modern education. And, indeed, there is truth in this. A schism *is* perceptible; yet such must mark every new step of intellectual development wherever the New has become a power, and the question to be settled is, the definition of its just claims, as against the just claims of the Old. The past progress of education of civilized nations has had its central point in the study of language. Language is the great instrument through possession of which man is most distinctly separated from the lower animals; through use of which he is

[1] From the preface to the recently-published German translation of Tyndall's "Fragments of Science," revised by the writer, Prof. Helmholtz, for *Nature*.

able to share the experience and knowledge of other individuals of his time, as also those of past generations; without which each man would, like the lower animals, be limited to his instinct and to his own particular experience. That therefore the improvement of language was formerly the first and most necessary work of a growing race, and that the most refined perfection of its comprehension and its use is, and must ever be, the primary problem in the education of each individual, is undoubted. The culture of modern European nations has a peculiarly intimate connection with the study of the remains of antiquity; and, thereby, directly with the study of language. With the latter study was associated that of the forms of thought, which are coined in speech; logic and grammar, that is, according to the original meaning of the words, the art of speaking and the art of writing, both taken in the highest sense, have therefore been hitherto the natural hinge-points of mental education.

But while language is the means of handing down and preserving truth once recognized, we must not forget that its study teaches nothing as to how fresh truth is to be found. Similarly, logic shows how, from the proposition which forms the major of a syllogism, conclusions are to be drawn; but it can tell us nothing as to whence this proposition has come. He who will convince himself of its independent truth must, on the other hand, begin with knowledge of the individual cases which fall under the law, and which afterward, if this have been established, may doubtless also be accepted as deductions from the law. But only where a knowledge of the law is one which has been communicated by others, does it actually take precedence of knowledge of the deductions, and, in such a case, the treatises of the old formal logic assume their undeniable practical importance.

Thus all these studies do not themselves lead us to the proper source of knowledge—do not bring us face to face with the reality which we seek to know. There is therefore, undoubtedly, a danger in communicating to each one, by preference, a knowledge the source of which he has not personally contemplated. Comparative mythology and the criticism of the metaphysical systems can tell a great deal of how figurative word-expression has in time been exalted to the importance of real knowledge, and even become valued as ultimate wisdom.

While fully recognizing, then, the significance (not to be sufficiently appreciated) of the finely-elaborated art of communicating the acquired knowledge of others, and receiving in return such communications from others, in regard to the mental improvement of our race; while also recognizing the importance attaching to the contents of the classical writings, for the cultivation of the moral and æsthetic sentiments, for the development of an intimate knowledge of human feelings, conceptions, and conditions of culture; we must yet hold that an important element is wanting from the exclusively literary-logical mode of education; and that is the methodical discipline of the activity by which we reduce the confused material which meets us in the actual world, apparently (at first sight) ruled by wild chance rather than reason, to clear conception, and thereby make it fit for expression in speech. Such an art of observation and experiment, methodically developed, we have hitherto found in the natural sciences alone; and our hope, that the psychology of individuals and peoples, with the practical sciences of education and of social and political government based upon it, will attain the same end, can only be fulfilled in a distant future.

This new enterprise, prosecuted by natural science on new paths, has quickly enough yielded fresh and, of their kind, unheard-of results, evidencing what achievements human thought is capable of, where it can go the whole way from the facts to the full knowledge of the law under favorable conditions, testing and knowing every thing for itself. The simple relations, especially those of inorganic Nature, permit of our possessing such a penetrating and accurate knowledge of their laws, such far-reaching deduction of inferences from them, and the testing and verification of these by such an exact reference to fact, that, with the systematic unfolding of such conceptions (e. g., with the deduction of astronomical phenomena from the law of gravitation), there is hardly any other edifice of human thought which, for strict logic, certainty, correctness, and productiveness, can at all be compared with it.

I point out these relations merely with the view of showing in what sense the natural sciences are a new and essential element of human education; of indestructible importance, also, for all further development of this in the future; and that a complete education of the individual man, as of nations, will no longer be possible without a union of the past literary-logical with the new natural-science direction of study.

Now, the majority of the educated hitherto have been instructed only in the old way—have hardly at all come into contact with the work of thought in natural science; at the most, perhaps, a little with mathematics. It is men of this kind of education that our governments appoint, by preference, to educate our children, to maintain reverence for moral order, and to preserve the treasures of knowledge and wisdom of our forefathers. It is they, too, who must organize the changes in the mode of education of the rising generation; where such changes are required they must be encouraged or compelled thereto by the public opinion of the intelligent classes of the whole community, both men and women.

Apart from the natural impulse of every warm-hearted man to lead others to that which he has found to be true and right, there will be in every friend of natural science a strong motive to share in such work, in the reflection that the further development of these sciences themselves, the unfolding of their influence on human education, and, so far as they are a necessary element of this education, the healthiness of the future mental development of the people, depend on an insight being afforded to the educated classes, into the nature and the results of scientific investigation, such as is generally possible, without a personal engrossing occupation with these subjects.

And in proof that the need of such an insight is felt even by those who have grown up under the predominant linguistic and literary instruction, may be cited the large number of popular books of natural science annually published, and the eagerness with which lectures of a popular character on subjects in natural science are attended.

It lies in the nature of the case, however, that the essential part of this want, owing to the depth of its roots, is not easily satisfied. It is true that what science may have established and wrought out in solid results can, by intelligent compilers, be put together and brought into suitable form, so that a reader without previous knowledge of the subject may, with some perseverance and patience, understand it. But such a knowledge, limited to the actual results, is not properly that which we have in view. These books, indeed, compiled with the best intentions, often lead into devious paths. To prevent weariness, they must seek to rivet the attention of the reader by an accumulation of curiosities, whereby the image of science is rendered quite false. One often feels this when the reader begins from his own impulse to tell what he has considered important. Then there are the further objections that the book can give only word-descriptions, or, at the most, drawings representing more or less imperfectly the things and processes of which it treats; and that the reader's power of imagination is thereby subjected to a much greater strain, with much less satisfactory results, than that of the investigator or student who, in museum collections and laboratories, sees the things before him in their living reality. A portion of the difficulties named may readily be obviated in popular lectures, if, at least, some objects or experiments can be shown: the opportunities of doing so in Germany, hitherto, have been mostly very limited.

It appears to me, however, that it is not so much a knowledge of results of scientific investigations in themselves that the most intelligent and well-educated of the laity ask, but rather a perception of the mental activity of the investigator, of the individuality of his scientific procedure, of the aims at which he strives, of the fresh point of view which his work affords in reference to the great problems of human existence. There can hardly be any thing of all this in the properly scientific treatment of scientific objects; on the contrary, the severe discipline of the exact method requires that, in scientific treatises, only that be spoken of which is surely ascertained, hypotheses only where equivalent to the proposal of questions for further investigation, a certain answer to these appearing probable from the next progress of the research. A natural prudence recommends great rigor in this connection. For it is pretty much the same to the greater number even of the instructed hearers whether a man of science says "I know," or "I suppose;" they only ask after the result and the authority by which it is supported, not the grounds or the doubts. It is thus not to be wondered at if earnest investigators do not willingly shock the confidence of their readers in what the former may think true and demonstrable, by the enumeration of ideas of the correctness of which they do not feel themselves quite secure. These may be very probable, and may be expressed with ever so much prudence and careful guardedness; they still expose him who utters them to the danger of vexatious misrepresentation.

It is, further, not to be overlooked, that the peculiar discipline of scientific thought which is necessary for the most abstract and rigorous grasp possible of newly-found ideas and laws, and for the purification from all accidents of the sensuous order of phenomena, along with the habitual residence of the mind among a circle of ideas far removed from general interest, is not a quite favorable preparative for a popular intelligible exposition of the insights obtained, to hearers who have not had the like discipline. For this task there is rather required an artistic talent of exposition, a certain kind of eloquence. The lecturer or writer must find generally accessible stand-points from which he may call forth new representations with the most vivid distinctness, and then allow the abstract principle, which he seeks to make intelligible, to derive from these concrete life. This is almost an opposite mode of treatment to that which obtains in scientific treatises, and it can readily be understood that the men are rare who are equally fitted for both these kinds of intellectual labor.

Owing to all these circumstances, a sort of dividing wall is raised between the men of science and the laity who might obtain instruction and guidance from them. That many, and indeed some of the most able, investigators have the qualities and peculiarities belonging to abstract work is natural, and will, in each individual case, be at once willingly excused. I have here merely to guard against the reversal of this relation, as if the defects named were necessary, or at all constituted a prerogative.

The compilers can give no help in those directions where the original thinkers have neglected or avoided expressing themselves. So much the more gratifying is it, I consider, in such a state of things, when, among those who have shown the highest ability for original scientific work, there is found, at times, a man like Tyndall, full of enthusiasm for the problem of making the newly-acquired insights and outlooks of his science available for the wider circle of the people, and, at the same time, endowed with other qualities which are the necessary conditions of success toward this end, eloquence and the gift of lucid exposition.

In England the custom of popular scientific lectures has been much longer in existence than in Germany. Since the constitution of the English universities is very different from ours, fewer individuals are there in a position to prosecute scientific research, or give scientific instruction to regularly prepared scholars, as their life-calling. This generally makes it much more difficult for individuals to go deeply into a special department of study, though genius of course everywhere breaks through these and other hindrances. The same circumstance has, on the other hand, maintained a closer connection of the workers in science with all other classes of the population, and incited to a more liberal care for the instruction of the student not regularly trained. While this has hitherto been quite rare in Germany, there have long been in England solid and well-furnished institutions for the purpose.

In the two circumstances, first that in England courses of a moderate number of connected lectures can be delivered, and secondly that this can be done in buildings well suited for demonstrations and experiments of every kind, there is a great advantage over the general custom in Germany, where each lecturer only delivers one lecture.

Now, it is intelligible that during the seventy years since this state of things has arisen, and under so much more favorable external conditions, the English public have educated their lecturers, and the lecturers their public, much better than has hitherto been the case in Germany. The Royal Institution has had, among its professors, two men of the first rank, Sir Humphrey Davy and Faraday, who have coöperated to that end. At present Prof. Tyndall is held in peculiarly high esteem, both in England and in the United States, on account of his talent for popular expositions of scientific subjects. Any one who is conscious within himself of the gift and the power of working in a particular direction for the mental development of humanity, has usually a pleasure in such activity, and is ready to devote to it a good share of his time and his energies. This is especially the case with Prof. Tyndall. He has, therefore, remained true to his post at the Royal Institution, though other honorable posts have been offered him. But it would be quite an erroneous conception to think of him merely as the able, popular lecturer; for the greater part of his activity has always been given to scientific investigation, and we owe to him a series of (in part) highly-original and remarkable researches and discoveries in physics and physical chemistry.

In his discourse "On the Scientific Use of the Imagination," delivered before the British Association at Liverpool, Prof. Tyndall has given a peculiarly characteristic description of his manner of intellectual working. There are two ways of searching out the system of laws in Nature—that of abstract ideas, and that of thorough experimental research. The former way leads ultimately, through mathematical analysis, to an accurate quantitative knowledge of the phenomena. But it can only advance where the other has already, in some measure, opened up the region, i. e., given an inductive knowledge of the laws, at least, for some groups of the phenomena belonging to it, and the point is merely the testing and clearing up of the already-found laws, the passage from them to the last and most general laws of the region in question, and the complete unfolding of their consequences. This other way leads to a rich knowledge of the behavior of natural substances and forces, in which at first the law-element is recognized only in the form in which artists perceive it, through vivid sensuous contemplation of the type of its action, in order to a later working out of it in the pure form of an idea. These two sides of the physicist's work are never quite separate from each other, though sometimes the diversity of individual gifts will adapt one man for mathematical deduction, another for the inductive activity of experimentation. Should the first method, however, become wholly divorced from actual observations, it falls into the danger of laboriously building castles in the air, on unstable foundations, and of not finding the points at which it may verify the agreement of its deductions with fact. The second, on the other hand, would lose sight of the proper aim of science, if it did not work toward ultimately bringing its observations into the precise form of the idea.

The first discovery of laws of Nature previously unknown, that is, of new forms of likeness in the course of apparently unconnected phenomena, is a matter of sense (taking the word in its widest meaning), and must nearly always be accomplished only by comparison of numerous sensuous perceptions. The perfection and purification of that which has been found fall afterward under the working of the deductive method of thinking, and preferentially of mathematical analysis, as the final question is ever about equality of quantities.

Now, Mr. Tyndall is *par excellence* an experimenter; he forms his generalizations from extensive observations of the play of natural forces, and carries over what he has seen, in some cases to the greatest, in others to the smallest relations of space (as appeared in the lecture referred to). It is quite a mistake to consider what he calls imagination as mere fancy (*Phantasterei*). It is exactly the opposite that is meant—full sensuous contemplation. To this mode of working is evidently to be attributed the clearness of his lectures on physical phenomena, as also his success as a popular lecturer.

EDITOR'S TABLE.

THE AMERICAN SCIENTIFIC ASSOCIATION.

THE American Association for the Advancement of Science held its twenty-third meeting at Hartford, in August, under the presidency of Dr. Le Conte, with a very good attendance. The address of the retiring president, Prof. Lovering, was an elaborate and able document, devoted to the discussion of prominent questions in modern physics; and a large number of miscellaneous papers, of the usual interest, were contributed to the proceedings. But while the Hartford meeting was one of average interest, in respect of the amount and quality of its scientific work, it was especially important in relation to the history of the domestic management of the Association. The constitution was revised, and the revision had reference to old and radical difficulties in the organization. As the American Association is the leading representative of the interests of American science, and as there is not a little misapprehension on the part of the public regarding its aims and policy, it will be desirable to give a brief account of its origin and character, that the import of the recent changes may be made intelligible.

The usefulness of organizations for the promotion of scientific objects is nowhere questioned. It is indispensable that scientific men should associate in order to carry on their work, and societies devoted to scientific objects, general and special, have accordingly sprung up within the last two centuries in all the leading civilized nations. The astronomers, the botanists, the geologists, the zoologists, the chemists, have all had their societies for the promotion of research and the extension of knowledge in their respective departments, while other institutions have aimed at the same ends by more comprehensive plans of organization. These associations naturally confined their membership to the cultivators of special original research in their several departments. But, with the rapid growth of science in later years, with the multiplication of its interests and the recognition of their powerful bearing upon public welfare, it began to be seen that the old organizations were inadequate to the general wants, and that new associations must be called into existence better adapted to meet them. One of the earliest expressions of this tendency was seen in the formation of the "British Association for the Advancement of Science," which was established in 1831, and held its first meeting at York, under the presidency of Earl Fitzwilliam, F. R. S. It was to be of a migratory character, holding its annual sessions in different towns; and it admitted to membership all who attended the first meeting, and in general all members of scientific societies, scientific professors, and those devoting themselves in any way to the promotion of scientific objects. There was obviously no intention that membership of the British Association was to be used or construed in the way of valuable indorsement of scientific position. The objects to be attained were general, and by no means the least of them was to act upon the public mind in such a way as to awaken a taste for scientific pursuits, to diffuse information, and incite an increasing interest in scientific matters. The aim of the organization was thus stated in the constitution: "The Association contemplates no interference with the ground occupied by other institutions. Its objects are—to give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the British Empire, with one another, and with foreign philosophers; to obtain a more general attention to the objects of science, and the removal of any disadvantages of a public kind which impede its progress."

Two classes of institutions for the promotion of science, having the same general object, but working by different methods, were thus in operation in Europe when the question arose of forming a scientific association in this country. But the circumstances were so different here as to occasion perplexity at the outset in regard to its plan. In England, France, and Germany, there are old institutions of high character, like the Royal Society, the French Academy, and the leading universities, which carry out a stringent system of discriminations in regard to the claims and position of scientific men, and whose honors are so difficult of attainment that they become passports of character throughout the world. There were no such venerated and authoritative establishments in this country; and, when it was contemplated to enter upon the organization of a prominent and permanent society for the promotion of science, there were grave apprehensions that, in the absence of established tests, such a body would be inundated with inferior and incompetent men who would degrade its standards, impede its true work, and, perhaps, pervert it to unworthy objects.

The Association of American Geologists and Naturalists was established about 1840, ten years after the British Association. The geological surveys undertaken by the different States rendered meetings of those engaged in them very necessary, for comparisons, discussions, systematic effort, and the attempt at some common basis of geological classification. Very naturally it was a society of working men—of actual investigators—and aimed at objects which belonged to the province of original inquiry. In 1848 this society was reconstructed, and merged in a new organization called the American Association for the Advancement of Science, its first meeting being held in Philadelphia, under the presidency of William C. Redfield, Esq. In this change the original society was widened in its scope, and conformed to the general plan of the British Association. Its objects are thus stated in the constitution: "The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse and a more systematic direction to scientific research in our country; and to procure for the labors of scientific men increased facilities and a wider usefulness."

In comparing the statements of the objects of the two Associations, it will be seen that they are in certain respects identical, the English phraseology being adopted by the founders of the American Association to indicate its purposes. But the American organization, in the presentation of its objects, omitted an essential feature of the English, confining itself quite strictly to the promotion of the interests of scientific men as investigators, and omitting the English phrase, "to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress." In a land preëminently of popular institutions, the new organization was less popular, in aim and spirit, than its foreign prototype—an anomaly which finds its explanation, as we have seen, in the circumstances under which American scientific men were laboring.

How early this feeling was entertained, and how serious were the apprehensions to which it gave rise, are well attested by the following passage from the address of Prof. Bache before the Association at Albany in 1851. No man could speak with more authority, as he was among its founders, and presided over its third, fourth, and fifth meetings. He said: "When the effort was first made to establish a general American Association for the Promotion of Science, it is certain that it met with considerable opposition. There were various reasons for this. From close communication with many who are now active members of the Association, I know why this fear prevailed over their hopes of the usefulness of such an institution. The opposition came not more from those who were habitually conservative, than from those who, being earnest in regard to the progress of science, are usually in favor of all progressive measures. It proceeded from no under-estimate of the strength which there was among the cultivators of science. Some of us had studied the workings of the British Association, and had been convinced of the absolute necessity for the attendance there from year to year of the men of the universities, to give tone to the proceedings, and were alarmed, perhaps, at the forays into the domains of science, which had there been witnessed in some of the less powerful sections, and even into the park of Section A itself. So far from having been trained in the same schools, we scarcely knew each other personally. How could we irregulars venture into conflict, when the files to our right and to our left were strangers to us, and when the cause might thus have suffered from the want of discipline of its volunteer support?"

The difficulties thus anticipated made their appearance. It may be not quite just to say that they were provided for, but a course was pursued which could hardly fail to bring them on. The American Association for the Advancement of Science was organized on the general plan of the British Association; its meetings were to be held in different places, as if to create a public interest in science; the membership was made easily accessible, and the form of proceedings was the same. But while the British Association has had in it a strong popular element, which has been regarded as perfectly legitimate, while it has aimed to awaken sympathy for science, and arouse an interest in it on the part of the people, by providing addresses to be delivered during its meetings to popular audiences, by including a wide range of subjects of public moment in its sectional discussions, and by giving earnest attention to the general subject of scientific education, all these things have been studiously avoided by the American Association, which has constantly maintained that its function is the *creation* of science and not its *diffusion* or popularization. Its title has misled the public from the beginning. It is not an Association for the Advancement of Science, in the full or comprehensive sense of the expression, or as interpreted by the institution which first adopted it. Had it chosen a title which accurately described its character, such as "An Association for the Promotion of Science by Original Research," misunderstandings would have been avoided, and the difficulties feared at the outset might have been escaped. There would then have been a distinctive basis of membership; nobody would have been admitted that had not done something in the way of actual research, and the work of these would not have been embarrassed and impeded by the interference of outsiders. But in the actual working of the institution these difficulties have arisen. A portion of the membership, who claim to be the investigators for which the Association was established, complained that their proceedings have been hampered and overborne by the influx of scientific nobodies; and the said nobodies have complained that the concern was managed by a self-constituted and exclusive ring, who have spent as much time in admiring each other as in their proper work, and have used the Association for the advancement of their personal objects and interests.

Dissatisfied with the results of this organization, several of its founders and most prominent members drew off in 1863 and organized the National Academy of Sciences. Its plan was an imitation of the French Academy; it allied itself to the General Government by which it was incorporated, and was limited to fifty members, with whom was the power of filling any vacancies that might arise. Here at last was an American institution sufficiently exclusive for the most exacting, and which could not be meddled with by the crowd of charlatans and incompetents without. It would seem that this arrangement, by giving original investigators a field of their own, ought to have met the difficulty and opened the way to the management of the original Association in a more liberal spirit. It is hardly too much to have expected that, when the National Academy had been organized on a basis which gave the most perfect protection to original investigators, and thus removed a serious American difficulty, the American Association might have widened its scope and placed itself upon the broad ground occupied by the British Association. But such has not been the effect. Instead of extending its scope and laboring to increase its general influence, the new constitution just adopted holds to the original aim of the Association, and concedes nothing to the growing popular demand for scientific guidance and enlightenment. Its main concernment seems to be still about scientific dignity, and it has actually entered upon the funny experiment of creating distinctions and distributing honors among its members. The old and troublesome question, "Who shall be greatest?" still vexes the souls of the managing magnates, who have solved it by the ingenious procedure of creating an order of "fellows." We have characterized this proceeding as funny, but if the bare fact be held as insufficient to justify such a characterization, then we have the further circumstance that the whole rabble of the membership are allowed to become "fellows" by the extra payment of two dollars apiece, which we think is certainly a very puerile piece of business.

We have very great respect for this Association, and believe that, notwithstanding its limitations, it has been productive of much good in this country. We have attended many of its meetings for the past twenty years, and found them instructive and profitable, while the past history of the organization affords ground of hope that it will be productive of still greater good in the future. But we believe that it would have been still more useful if it had been dominated by a broader spirit, and that as the interests of science are widening and deepening, and coming to be more generally recognized, it will be still more necessary in the future that the American Association for the Advancement of Science shall take them into earnest and systematic account.

NEW EXPERIMENTS IN EDUCATION.

It was an important step in the progress of knowledge when the bodily constitution of man began to be studied in the light of its relations to the inferior orders of life, and it promises to be a no less important step when the human mind is also so regarded. The study of mental manifestations in inferior creatures is becoming a systematic branch of inquiry, and the observers in this field are beginning to apply their method in the human sphere. We do not say that they have a new psychology, or claim to have arrived at any remarkable results; it is only noteworthy that those who have been engaged in discriminating among the mental likenesses and differences of horses, dogs, pigs, and parrots, are attracted to similar observations upon the young of the different races of men.

Dr. W. Lauder Lindsay, a physician in charge of a Scotch lunatic asylum, but who has long been a special student of the subject of mind in animals, has sent a brief communication to *Nature*, giving the results of some experiments upon the mental capacities of children of different racial descent. The observations were made by Monsieur J. C. Houzeau, also a comparative psychologist, and author of "Studies on the Mental Faculties of Animals compared with those of Man." The observations were made in Jamaica, upon children inhabiting that island, and M. Houzeau states his experiments and conclusions as follows, in a letter to Dr. Lindsay:

"I have been busy, meanwhile, on a curious study about the comparative development of intelligence of children belonging to different races. I had an opportunity here to submit to the test black, brown, and white children. Fifteen of them were sent to me every day for two hours by their parents, my country neighbors: three of them white, seven colored of various shades, and five black. For a whole year I gave them myself common instruction, and carefully watched their proceedings and their rate of improvement. I do not expect to publish any thing about that experiment, at least at this time. But I will state here the conclusions to which it has led me:

"1. There is in each child a different degree of intellectual proficiency, which could be called, in mathematical language, his or her 'personal coefficient.' However, these individual differences are much less than I had anticipated, and are not the striking feature in the unequal rate or speed of improvement.

"In this unequal speed, I see nothing—at least nothing clearly and unmistakably discernible—that can be referred to the differences of race. This will probably appear strange after all that has been said of 'inferior races.' Should other facts show that my experiment was not properly conducted, and that the trial was not conclusive, I am ready to give up. Still, it is at least my 'provisional conclusion.'

"The rate of improvement is due almost entirely to the relative elevation of the parental circle in which children live—the home influence. Those whose parents are restricted to the narrowest gauge of intellectual exercise, live in such a material and coarse *milieu* (medium), that their mental faculties remain slumbering and gradually become atrophied; while those who hear at home of many things, and are brought up to intellectual life, show a corresponding proficiency in their learning."

Experiments upon so small a scale, and continuing for so short a time, must, of course, be inconclusive, for, as Dr. Lindsay remarks, "at or up to a certain age, girls are as sharp as or sharper than boys at lesson learning and repeating. Cases are constantly being recorded—perhaps paraded—in the newspapers of girls or young women beating boys or young men of equal age in competitive examination, and yet it is not to be inferred that the female mind is either superior or equal to the male, that is, in a comparison of averages. For the fact is, that, throughout the animal series, including man, the female mind, is, in some respects, different from, and inferior to, that of the male. We know, moreover, that female superiority, when it exists, is usually at least confined to school-life. In subsequent intellectual development proper, man, as a rule, far surpasses woman."

But, while M. Houzeau's observations were quite too restricted to form a basis of useful conclusions respecting the educability and intellectual capacity of the children belonging to different races, there is great significance in his final conclusion regarding the potency of home influences. This is no new truth, but it is a truth of transcendent importance, too much neglected, and its confirmation under such peculiar circumstances is noteworthy. That the medium in which the child is habitually immersed, and by which it is continually and unconsciously impressed, should have much greater value in the formation of mental character than the mere lesson-learning experiences of the school, and should, in fact, determine the efficiency of the school-agencies themselves, is simply inevitable. Whether a child has the advantages of a quickening home, or is the victim of a stupefying home, is of far more moment than the quality of the school it attends. Home education is, after all, the great fact, whether it awakens or whether it quenches the young minds exposed to it, and it becomes a momentous question whether our exaggerated estimate and desperate cultivation of school-houses and public education are not at the expense of the far more important domestic influences by which the characters of children are formed. For we are learning every day that, as this world is constituted, one thing is at the expense of another. If parents believe that the school is all in all, and can do every thing for their children, such are the pressures and strains of social life that they will evade and neglect their own responsibilities. Their children will be committed to stupid and vicious servants, hustled out of the way, turned into the street, or left to themselves; and no pains will be taken to make the home medium one of elevation, stimulation, and improving to the mental characters of their offspring. Where men are exhausted in business, and women are exhausted by society, and there is blind faith in teachers and school-rooms, we may be pretty sure that but little will be done to shape and conduct the home with reference to the higher mental needs of the children who live in it. There are, no doubt, noble examples of parents who appreciate schools and strive to do their corresponding part of the work of exalting and enriching the intellectual life of those committed to their charge; but such cases are lamentably few, and there is reason to fear that, with the increasing faith in public appliances of culture, their proportion will not increase very rapidly.

PROFESSOR TYNDALL'S ADDRESS.

We publish in full the masterly inaugural address delivered August 19th, before the British Association at Belfast, by Prof. Tyndall, its President, for the present year. No scientific paper ever before published has produced so extensive and profound an impression as this. The eminent ability of the speaker, the dignity of the occasion, the confessed importance of the subject, and the eloquence and power of the statement, have all concurred to this result; but it has also been greatly due to that rapid diffusion of information upon the general question which has taken place within the last few years, and to the ripening of public judgment that has followed. In regard to this, Prof. Tyndall has calculated with great sagacity. Could the question have been submitted to the intelligent classes as to the propriety of such an experiment, probably nine out of ten would have condemned its folly and predicted its failure. Yet the address has actually been received with a unanimity of commendation that has fairly bewildered those who make it a business to study the drifts and currents of public sentiment. Some of the leading organs of public opinion, however, still affect to think that Prof. Tyndall has made a mistake, and that to spring upon the public mind this hitherto obnoxious discussion, under such peculiar circumstances, was in a high degree unwise, injudicious, and impolitic.

For example, the *Saturday Review*, while according to Prof. Tyndall's address much qualified praise, is still dissatisfied and captious, and objects to it as follows: "We confess that we were surprised that the President so wholly abandoned himself to elaborating one idea, and that one so distasteful to a large portion of those interested in science. . . . He has more than once, it is true, incurred great odium by the outspoken way in which he has declared his opinions, and he has been pronounced rash for so doing; . . . we do not see why those who are not framed for special researches, but rather for being spokesmen of science, should bring odium upon it by trumpeting forth on occasions like these such of their beliefs as are most controverted even among themselves, and are most objected to by a large part of the outside world." And, speaking of his selection of a subject, the *Review* concludes that "while we fully appreciate the honesty of his motive which led to the choice, we much doubt its wisdom." The *New York Tribune* is even more decisively of the same opinion. It declared that "every sensible man will deeply regret that the address was ever delivered;" and, in a subsequent editorial, it reaffirms the judgment, "regarding Prof. Tyndall's demonstration as utterly unwise and unnecessary."

The question here raised is, by what kind of motives ought a man to be governed who has a great public duty to discharge as the representative of a body devoted to the advancement of scientific thought? Shall he meet his responsibilities like a man, or shrink from them like a coward? Shall he speak with honest fearlessness, or with a calculating caution? It is admitted on all hands that Prof. Tyndall chose the former alternative, and that his address was bold and courageous. This means, if it means any thing, that there was resistance to be overcome, and that it was so great as to call for the highest qualities of character to overcome it. There were ignorance, prejudice, narrowness, misunderstanding, and intolerance, in regard to a grave subject that had grown up in the world of science. A great opportunity came to him to treat this question as science treats all questions, to place it in a new light, and fix the world's attention more closely upon it. He might have taken counsel of prudence and timidity, and refrained from stirring up the disagreeable elements of hostility to an unpopular doctrine. But, pray, what are the circumstances in which the bold and courageous utterance of unacceptable opinions is to be ever justified? Can it be denied that the problems taken up by Prof. Tyndall are of transcendent importance, and are universally so regarded? And, if they were legitimate to discuss at all, what reason can be given for not treating them with the utmost thoroughness? Prof. Tyndall might, no doubt, have shirked the subject, to the comfort of many, and taken up some commonplace topic that would have disturbed the tranquillity of nobody. But there are plenty of men to rehearse the platitudes of science on occasions like this; and when one appears with the power of stirring the intellectual world to its depths, by the commanding treatment of a great theme, if he makes the utmost use of his opportunity, we see no reason for deploring it. More than this, he has no option in the matter; he is bound to be up to the utmost requirements of his duties and responsibilities. We offer no excuse for Prof. Tyndall, in taking the course he did—it would be an impertinence. He was forced by an obligation of honor to use his best powers for the advancement of the broad objects of the Association over which he presided; and his use of the occasion to vindicate the rights of scientific inquiry was the noblest service that he could perform. It has been said that his argument is superfluous, and that science has already the fullest liberty of investigation. It is true that the laboratories are not disturbed by the police; it is true that investigators are at liberty to publish their proceedings; but it is not true that the advance of science is without impediments and restrictions, nor is it true that men of science are left in perfect freedom to push their investigations undisturbed, to the utmost boundaries of knowledge. If they pass into certain departments of thought where there are facts and phenomena to be known, and knowledge is to be extended, they are denounced as impious intruders; and we can no more say that the mind is free in its action when loaded with execration for taking this or that course, than we can say that the body is free in its movements when loaded with chains. Prof. Tyndall came to this country to lecture upon physics. He stuck strictly to his text, and raised no questions in regard to the scope of scientific inquiries. But he was not let alone. At the banquet he received before leaving us, he was lectured upon the subject of the limits of science, and in the name of religion was bidden to keep in his place, and not attempt to solve the great questions of the origin and end of the world by running his head into the mud of mere physical speculation. Those things, he was told, are not for science, but belong to philosophy and revelation. The fundamental question of the Inaugural Address was thus here publicly thrust upon him from the religious side, and he was instructed what it was proper and what it was not proper for him to do as a scientific inquirer. Both the wisdom of the instructions and the propriety of giving them were extensively indorsed by the press of the country. Prof. Tyndall was, therefore, not let alone, and left free to pursue his course as a scientific man, but his course was dictated to him by the party that does not make science its business. His critics now have their reply, and we hope it is satisfactory. That he has not minced matters, but has met the issue manfully and squarely, we think is to the credit of the side he represents.

In wholesome contrast to the time-serving lamentations above quoted, we give some passages from an editorial in *Church and State*, a religious newspaper, which shows a heartier appreciation of Prof. Tyndall's work:

"It is one of the most conspicuous benefits of the study of physical science, that its most difficult and fundamental problems may be approached with absolute honesty. To find out the exact truth, whatever it may be, and to give it accurate expression, is the very business of science. The most skillful and successful investigators are always searching for new facts, by which their own provisional conclusions and working hypotheses may be either verified or corrected. They are so far from resenting new discoveries, that they themselves expose to view the weak places in their theories and generalizations, with the very object of calling universal attention to their *weakness*. They understand no triumph except the triumph of seeing for themselves, and helping other people to see, *that which is*.

"It is surely a gain to theology and religion that the most influential thinkers of our time—for it would be idle to deny that 'science' is the fashion—are pledged, not only by their own high character, but by the very nature of their pursuits, to absolute truthfulness, and to the most unflinching courage. Even Biblical interpretation would gain largely—and has, in fact, achieved all its modern triumphs by its adoption of an inductive method. Instead of setting out with certain authorized dogmas, and finding 'proofs' for them, somewhere or other, in the sacred Scriptures, our modern scholars set out with some book of Scripture, ascertain its authorship, its date, the readers for whom it was intended, the circumstances in which it appeared, and *its actual meaning*.

"And when we approach the ultimate problems, not only of religion, but even of life, it is well that we should be made to understand what the issues really are; and Prof. Tyndall has rendered us this service in his address to the British Association—an address so brilliant and noble that we have to lay it aside for a while, and come back to it, for sober criticism, in a calmer mood. No doubt, on both sides, it will be misrepresented, but there it is—stating questions that must be answered, facts that must be accepted and included in any theory either of mind or matter. We shall hope to give a fuller account of it before long; but its concluding words are worthy of the most solemn consideration of all of us who love the truth, however widely we may differ in our conclusions from Prof. Tyndall himself."

LITERARY NOTICES.

The Science of Law. By Sheldon Amos, M. A., Professor of Jurisprudence in University College, London. International Scientific Series, No. X. 417 pp. Price $1.50.

Prof. Amos has written a book which will prove peculiarly acceptable at the present time; for, although discussions in respect to the application of the scientific method to social affairs are becoming commonplace, there is, nevertheless, a profound interest in the general question, and there is certainly a strong desire to know what can be done by that method in a field which is at once so practical and so unpromising as that of law. Whatever may be said about it, it is an undeniable fact that science has effected a foothold and begun to make itself at home in social inquiries, and it is certain not to go backward in the future. Moreover, in no region of thought have greater changes already occurred in the modes of inquiry than in the study of society. The old conceptions of history as the exponent of social life and progress are declining, and in their place we see steadily growing the conception of society as a sphere of phenomena in definite relations, to be analyzed, described, and classified, in the same way as any other department of Nature. Facts are to be observed and generalized, uniformities traced, and inductions established, not exact, of course, as in the exact sciences, but with the utmost degree of accuracy that the case admits, until our knowledge of the subject shall be reduced to scientific order. The group of social phenomena that are termed legal affords no exception to this tendency. Jurisprudence, indeed, has not formerly been wanting in its scientific form; in fact, it could not be systematically dealt with at all without involving the rudiments of a scientific method; but later investigations have tended increasingly to show how arbitrary and insufficient these methods were. The work of Prof. Amos is at the same time a landmark of progress and a reëxposition of legal facts and principles in the direction which is certain to be pursued in the future.

The two English writers, leaving out Bentham, whose labors have done most in developing the science of law, are Austin and Maine. Though both expositors of the same subject, they worked in entirely different ways. Austin, after describing the nature and province of law, examined and analyzed the fundamental conceptions which are common to all legal systems, and deduced from such analysis the principles of logical classification. In accepted language Austin occupied himself with the philosophy of law. On the other hand, Maine takes legal institutions as they are and have been, and traces them back to their earliest forms. He brings into full view the order of evolution and the influences which determined the course and progress of legal ideas. These two methods, the historical and analytical, are not opposed to each other as competitors, one of which must prevail. They really complement each other; the fruits of both are needed; they run into each other at every point. In our opinion, there is still another line of inquiry which must be taken up to complete the explanation of legal phenomena. Laws are made to effect definite purposes; they are the means by which certain actions and relations of mankind are regulated. Law-making is surrounded with the most difficult problems, and has for its only guide considerations educed from experience and the constitution of human nature and society. These purposes and, to a certain extent, these problems, the student of law must investigate; to stand outside, refusing to touch them, invites fatal criticism. We should say, then, that the scientific treatment of law includes the analysis and classification of legal conceptions; inquiry into the origin and evolution of legal institutions; and the theory of legislation. Prof. Amos adopts this view, and it colors every chapter of his work. He has dared to be comprehensive, and so has given us a treatise which will have a permanent value. Every department of law is explored in the directions indicated, and with all the fullness that can be expected in a popular book. The author travels over a wide field; and he is a guide that turns the attention of his readers to every part, pointing out the most important features with unusual skill and exactness.

Such being the general plan of the work, the author commences the treatment of the subject by devoting the first three chapters to certain preliminary matters relating to the recent history and present condition of the subject, the province and limits of the science of law, and an analysis of the relations of law and morality. In the following chapters we have an account of the growth of law, and this statement is exceedingly interesting. The steps in the evolution are distinctly marked, the manner in which the changes were effected are clearly traced, and the sources whence materials were drawn for the constant process of improvement are pointed out. The latest and best-credited speculations on the origin of law, customs, equity, and methods of legislation, are also carefully presented. The sixth chapter is an analysis of primary legal terms, such as "person," "thing," "right," "duty," "act," "event," "intention," etc., all of which have complex meanings in jurisprudence. Separate chapters are given to such subjects as contracts, ownership, crimes, procedure, international law, and codification; and these are all treated with admirable clearness.

This little book deserves to be widely welcomed by the reading public. The names are few, in the list of great writers belonging either to this country or England, who have made contributions of any weight to legal sicence; Prof. Amos comes forward to do what he may toward supplying this deficiency, and he has proved himself equal to the task. He has produced a work on the science of law which will not only have its interest for the legal profession, but will have a greater interest beyond that profession. It has not been written for the specialist, but for general readers, and conveys in a popular form a kind of knowledge which has never before been reduced to convenient shape for general acquisition. And in this country especially, where everybody is or ought to be more or less concerned in the work of law-making, and where principles are required for guidance in the discharge of this duty, a work which strips the subject of its arbitrary and local features, and develops its universal and scientific aspect, should be widely welcomed and carefully studied.

It is proper to remark in this place that Prof. Amos has undertaken a formidable task in first attempting so great a novelty as to educe the general principles of the science of law, and then to present them in a compendious form adapted to all classes of intelligent readers. It was impossible that a pioneer work of this sort, dealing with subjects which have been habitually regarded from other points of view, should not be very tempting to critics who are ever on the lookout for something to slash; and we note that some of the English periodicals are very free in their strictures upon the professor's book. But, although finding fault with some of its minor points, its main characteristics have not been assailed, and the practical value of the treatise is conceded in all quarters. It supplies an urgent and an undoubted want, and will be a valuable addition to the "International Series" for which it was prepared. J. G. M.

The Relations of Christian Educators to the Modern Phases of Science. By Daniel S. Martin, A. M., Professor of Geology and Natural History in Rutgers Female College. From the Proceedings of the University Convocation, held at Albany, 1873.

We have read this address with much interest, as it comes from a thinker who views the subject from both its sides—that of a thorough mastery of the modern problems of science, and that of the most stringent orthodoxy. He therefore not only recognizes "the fact of a long and lamentable controversy between Christian and scientific modes of thought," but he sees that both parties are at fault in provoking and maintaining it. On the scientific side, the causes of alienation are assumed to be—1. A "disposition to exclude the idea of God, which has appeared so strangely in the writings of scientific and philosophical students," and which he is unable to explain except on the hypothesis "that the whole race is in some way morally perverted and alienated from God and all true excellence;" 2. "Apart from an absolute and intentional advocacy of atheistical ideas, there is, on the part of many scientific men, a carelessness, or even a hostility of expression toward religious truth which awakens deep distrust;" 3. The perversions and misrepresentations of pretenders to science who assume its name to assail religion.

On the religious side, the causes of conflict pointed out are: "1. The absorbing claims and responsibilities of the ministerial calling, and the overshadowing weight of great moral themes; 2. A lingering half-doubt as to the legitimacy of the spirit of universal investigation; and, 3. A want of sympathy and intercourse with men of scientific pursuits." To these is added the want of a proper scientific education on the part of religious students, and to this the writer adds: "One of the last and most important points worthy of especial mention, as a cause of difficulty and alienation, is the harsh and captious mode of speech employed by many religious and other critics toward the views of men of science. How freely are such terms as 'infidel,' 'materialist,' 'unbeliever,' etc., applied to men who have really neither made nor intended any unkind allusion to religious men or religious truth, but whose discoveries have led them to the presentation of views which, marking an advance in scientific conceptions, involve, perhaps, some changes in the outward form of conceiving certain scriptural statements! Instead of calm and fearless inquiry, they are met with stern and positive denunciation. Instead of looking to see what new and valuable expansion of even our scriptural conceptions may be found, many religious men at once raise the cry of infidelity, and force the unhappy investigator of Nature into a position of hostility which he never designed to assume. I myself was never more surprised than on finding the magnificent generalization of the unity and convertibility of material forces assailed on charges of this kind."

The Philosophy of Spiritualism, and the Treatment of Mediomania. Two Lectures. By Frederic R. Marvin, M.D. New York: Asa K. Butts & Co. 12mo, 63 pp. Price, $1.00.

The well-known doctrine of the correlation and equivalence of forces is here called in to account for the phenomena of spiritualism. Assuming that thought is the utilization by the brain of a force correlative and interchangeable with the other forces of the universe, it follows that the force thus utilized may be converted into other forms of force, and thereby made to move a table, insensibly communicate the thoughts of one person to another, and do many other seemingly inexplicable things. In this light a table, dancing over the floor by itself, and spelling out marvelous communications, is a very natural performance. It is the result of a train of forces set in motion by the brain of the medium, consciously or unconsciously, usually the latter. Thoughts long forgotten by a spectator, but still unconsciously present in his mind, may be unconsciously communicated to the medium, and by him revealed.

Mediomania is regarded as a species of insanity allied to hysteria, chorea, etc. It is produced generally by derangement of the sexual organs. Like other disorders, it is susceptible of treatment and cure. The book is interesting, and its conclusions are in accordance with the existing tendencies of scientific thought.

Manual of Geology: Treating of the Principles of the Science, with Special Reference to American Geological History. By James D. Dana. Second edition, with over 1,100 Figures, and a Chart of the World. 828 pages. Price, $5.00. New York: Ivison, Blakeman, Taylor & Co. 1874.

The first edition of this valuable work and standard text-book of American geology was published in 1862. It is now revised, much extended, and brought down to the present date, by incorporating the results arrived at by the most eminent investigators in various departments, among whom acknowledgments are made to Meek, Marsh, Worthen, Lesquereux, Hall, Newberry, Winchell, Gilbert, Wheeler, Collett, Knapp, Broadhead, Dawson, Billings, Johnson, Verrill, Hayden, Holmes, Gardner, Hawes, and Bradley. From such a wide range of contributions to so progressive a science as geology, the task of revision was most laborious, but it has been very thoroughly performed by the author, so that his work stands alone as an exposition of the present state, both of the general science of geology and its American applications. Nor is it merely a *résumé* of the latest facts; they have all been incorporated into the structure of the work, and, by contributing to the further advancement of the science, they give to the present volume greater unity and completeness than were possible in the first edition; for with the increase of knowledge the science has been perfected. Professor Dana recognizes the advances that have been made in elucidating the progress of life upon the globe, and gives in his adherence to the great doctrine of evolution, although entertaining speculations of his own in regard to the mode of its working. He admits that "the evolution of the system of life went forward through the derivation of species from species according to natural methods not yet clearly understood, and with few occasions for supernatural intervention." The modifications in the new edition which have reference to the doctrine of evolution are very significant.

The Ship of Fools. Translated by Alexander Barclay. 2 vols. Edinburgh: William Patterson. New York: Appletons. 1874. Price, $25.00.

This curious old book was written by Sebastian Brandt, a German ecclesiastic, two years after the discovery of America. It is a popular poetical satire, directed against the vices and follies of the times just before the Protestant Reformation; but the sorts of people that provoked Brandt to ply his satirical lash are not without representatives in our own day; and hence, as a book of instruction, the "Ship of Fools" is by no means out of date. Soon after its publication it was translated into Latin, Dutch, Low German, and French; and in 1509 it was rendered into English by Alexander Barclay. The work now possesses mainly a philological and bibliographical interest, and has been expensively reproduced in exact fac-simile, in type, text, and illustrations, of the original edition. The English version is rather an adaptation of the original to English modes of life than a mere translation. It is well observed in the introduction: "Barclay's 'Ship of Fools' is not only important as a picture of the English life and popular feeling of his time; it is, both in style and vocabulary, a most valuable and remarkable monument of the English language. Written midway between Chaucer and Spenser, it is infinitely more easy to read than either." The language is strongly Saxon. Of the original work it is said that, "for upward of a century it was, in Germany, a *book of the people* in the noblest and widest sense of the word; and it was assumed to be so familiar to all classes that, even during Brandt's lifetime, the German preacher, Gailer von Kaiserberg, went so far as to deliver public lectures from the pulpit on his friend's poem, as if it had been a scriptural text."

The Psychological and Medico-Legal Journal. New Series, No. 1. July, 1874. Conducted by William A. Hammond, M. D., assisted by T. M. B. Cross, M. D. $5.00 per annum. New York: F. W. Christern.

This is a continuation, in a new form, of Dr. Hammond's *Quarterly Journal of Psychological Medicine*, and it will probably take a more popular shape in its new phase of development. The leading article of this number is a complete report of the chief editor's address before the Neurological Society, on the "Effects of Alcohol on the Nervous System." It details the results of many experiments made by Dr. Hammond upon himself, to test the physiological influence of various forms of alcohol, and is an interesting and instructive contribution to the literature of the subject. The discussion which followed the address, by various physicians, is given; and there are several important notices and reviews of works upon psychological and medico-legal questions. The periodical is at present a monthly, but this is, perhaps, provisional. It is well printed, and has a neat and attractive aspect.

United States Commission of Fish and Fisheries. Part I. Report on the Condition of the Sea-Fisheries of the South Coast of New England in 1871 and 1872. By Spencer F. Baird, Commissioner. With Supplementary Papers. Washington: Government Printing-Office, 1873.

For many years, in this country and Great Britain, both popular and scientific opinions have been much vexed by the question whether the great harvest of the sea was not in danger of very serious diminution. It seemed to be generally thought, those only objecting who were engaged in such matters, that nets, wears, pounds, etc., were fast exterminating our food-fisheries. It was even argued by many fishermen that, when the hook and line only were used, they fared much better, in the long-run, than they have done since the pursuit has enlisted capital, and brought into requisition, like other departments of industry, the most effective methods. It was certainly true that, of some species, the diminution had become so serious, that what was once a cheap food had become an expensive luxury; and, in respect to others, the supply was so precarious, that the prices were always good, and sometimes oppressively high. In this state of things the fishermen made their appeal to legislation, and the legislators in turn referred the whole matter to the men of science. We remember an old Professor of Hermeneutics, who said in his manual that Science had its apostles as well as the Gospel. The sentiment gave offense to many of his co-religionists, and his publishers asked to be allowed to take out the objectionable sentence. The professor firmly refused: "For," as he said to us afterward, "my regard for truth would not permit it." The United States ordered a commission to attend to this matter. No salary is provided, and no perquisites are possible. Can the men be found who will speak with the force of authority, and without the inducement of hire? With Spencer F. Baird to lead, a noble band of workers take up the cause—Baird and Gill, the ichthyologists; Dr. Farlow, the algologist; Profs. Verrill and Smith, of Yale College, the one so famous on the polyps, and the other on the crustacea; Mr. Emerton and Prof. Morse, noted specialists in the invertebrata—and there were chemists and meteorologists also. And all without fee or hope of reward, beyond the consciousness of the great good that must ensue from the accumulation and distribution of trustworthy knowledge on the great question of conserving the food-fishes. It became necessary to search old, musty records of the Puritan days, in order to know what its supply was in times gone—the migrations of fish, their food, the actual climate of the waters they frequent, and where they are scarce, and their food. Hence came deep-sea dredgings, and thermometric soundings, and explorations of sea-bottoms, and the chemical condition of the waters in different places and at different depths, etc., etc. The results appear in part in this thick volume. Besides a large amount of work in their best vein, Profs. Baird and Gill have given catalogues of the fishes, and Verrill and Smith of the invertebrates. The work of the former gentlemen is yet incomplete, and another year must continue the publication. That of Verrill and Smith has a sort of completeness, and it is well that this part is republished; and, as it is accompanied by many illustrations, it is to the student of these forms invaluable.

Essays and Addresses, by Professors and Lecturers of Owens College, Manchester. London: Macmillan & Co. 560 pages. 8vo. Price, $5.00.

This volume is intended to commemorate the opening of the new buildings of the Owens College, which occurred on October 7, 1873. This college was founded in 1851, by a bequest of John Owens, a merchant of Manchester. In 1871 it was reconstituted and incorporated by act of Parliament. A sketch of its origin and progress is given in the "Opening Address" by the Duke of Devonshire, its president.

In the address "On Some Relations of Culture to Practical Life," Prof. J. G. Greenwood, the principal of the college, enters the controversy between the classical and scientific methods of education, and endeavors to stand upon middle ground. Instead of a principally classical curriculum, or the reverse, he would have one which embraces *letters* to cultivate the taste, *mathematics* to discipline the reason, "and some branch of *physical study*" to develop the powers of observation and inductive reasoning.

The lecture on "Solar Physics" is an interesting summary of our knowledge regarding the appearance of the sun, his atmospheric changes, his meteorological connection with the planets, and the connection between his magnetic changes and auroral displays.

"Primeval Vegetation in Relation to Natural Selection and Evolution" is a criticism, by Prof. W. C. Williamson, of those doctrines in the light of apparently contradictory facts furnished by the vegetation of the Cretaceous and Tertiary epochs. These facts are, that a great variety of forms appear to spring suddenly into existence, during those epochs, without the existence, in preceding epochs, of other forms from which they could have descended; and the presence of more highly-organized forms than we are led to look for on the grounds of either doctrine. The issue is made in a special, not a general sense. The general fact of evolution is taken for granted, while the special fact, that the implied variations of species are endless, is called in question. The position assumed is that such variations are limited.

In "Some Historical Results of the Science of Language," Prof. A. S. Wilkins draws a very entertaining picture of the condition, customs, and manners, of the prehistoric Aryan people, from glimpses afforded by the implications of the words they had in use; his object being to show what light has been thrown upon the distant past by the study of philology.

Among the remaining essays, "Original Research as a Means of Education," "The Distance of the Sun from the Earth," "The Limits of our Knowledge of the Earth," "The Use of Steam," "Science and Medicine," "Provençal Poetry in Ancient and Modern Times," "The Judicature Act of 1873, in its Relation to the History of the Judicial System of England," and "The Peace of Europe," will prove of interest to the general reader.

Report on the Geological Survey of the State of Iowa to the Thirteenth General Assembly, January, 1870; containing Results of Examinations and Observations made within the Years 1866 to 1869. By Charles A. White, M. D. 2 vols. imperial octavo, pages 391 and 435. Price $10.00. Des Moines, Iowa: Mills & Co.

The first four chapters of this work are devoted to the physical geography of the State, which is admirably presented. In the first of these the author considers the surface features of Iowa, and gives in a chart five profiles across the State, showing elevations above low water in the Mississippi at Keokuk. From these it appears that the highest point in the State is but a little over 1,200 feet above the lowest, and that these two points are nearly 300 miles apart. The drainage of the State consists of two systems of rivers, an eastern and a western system, emptying, the former into the Mississippi, and the latter into the Missouri. As there are no mountains, the rivers constitute the most conspicuous feature in the physical geography of the State, and all its irregularities of surface are due almost solely to erosion by streams. The inconsiderable lakes of Iowa the author divides into two classes, viz., *Drift Lakes*, those whose beds consist of depressions in the drift, dating from the glacial epoch, and *Alluvial Lakes*, formed by the action of rivers. In the second chapter we have a discussion of the origin of the drift, in which the evidences of its glacial origin are set forth with a degree of clearness which is truly admirable. The two remaining chapters of this first part are devoted to the consideration of soils and climate. The author offers no opinion as to the *origin* of the prairies, but he holds "without the least hesitation that the real cause of their present existence in Iowa is the prevalence of the annual fires. If these had been prevented fifty years ago, Iowa would now be a timbered instead of a prairie State."

In Part II., General Geology, the author considers, among other points, the question of practical coal-deposits, and is confident that coal may be sought for over the whole of Southwestern Iowa, with reasonable hope of finding plentiful supplies at available depths. The present known coal-area of the State is about 7,000 square miles. The existence of large quantities of good peat has also been fully demonstrated. Explorations for mineral oil or the precious metals in any part of the State are almost certain to end in failure.

In Part III. of the first volume, and Part I. of the second, those portions of the State which have been examined in this survey are, as far as practicable, subdivided into regions that have common geographical characters, for the purpose of facilitating their description. A general account of each region is followed by separate and more detailed descriptions of every county within it, so far as they have been examined. Finally, Part II. has four chapters on mineralogy, lithology, and chemistry. But space would fail us to signalize all the excellences of this work, which has the rare merit of being truly *readable* for the unprofessional and unscientific man. As regards the mechanical style of the work, it is in all respects admirable. The paper is of the best quality, the type large and clear, the proof-reader's duty faithfully done, and the woodcuts, charts, and plates, equal to the best. We would call special attention to the "Geological Map-Model" of the whole State. This consists of a map of Iowa in six sheets, whereof the lowest represents the Lower Silurian formation, underlying the entire State; over this the Upper Silurian, which covers all the foregoing except the extreme northeast corner; then the Devonian, which retires still farther back from the northeast corner; then in succession the sub-Carboniferous, the Lower and Middle Coal-Measures, the Upper Coal-Measures, and the Cretaceous.

A Plain Exposition of the Theory and Practice of Life Assurance, with a Brief Sketch of its History. By J. H. Van Amringe, Professor of Mathematics, Columbia College, New York City. New York: Charles A. Kittle, 765 Sixth Avenue. 1874. 8vo, pp. 61.

Life insurance is "a subject of which, though some of the details may be complicated, the first principles are singularly plain." So wrote De Morgan, thirty-six years ago; a period within which there have been created in America seventy life-insurance companies now existing, the details of whose business are before us; of whose policies about 917,000 are now in force, insuring about $2,331,000,000, with a yearly income exceeding $125,000,000, and holding assets amounting to $375,-000,000. These enormous sums are the insurances, and yearly and accumulated payments, in behalf of beneficiaries, who doubtless exceed 3,000,000 in number; and of fully nineteen-twentieths of these interested persons it is safe to say that they know nothing of the "first principles," so "singularly plain," of which De Morgan spoke, but of which he said, "nothing but indifference can prevent the public from becoming well acquainted with."

Of publications professing to popularize ideas about life insurance there are enough and a surfeit; but, the greater part of them being openly written in advocacy of some particular company, they are regarded by most people as advertisements, to be hastily read and carelessly cast aside. It seems, therefore, that, for an authoritative exposition of the principles and practices of the business, the public will regard the more such a presentation of the subject as has now been made of it by Prof. Van Amringe, who, from his position, will not be suspected of writing in the interest of any company or class of companies.

In his preface the author says: "The object of this pamphlet is to dispel the apparent mystery which envelops assurance—to give the general reader a clear and concise explanation of the principles on which it is founded, and their application in business. Purely technical discussion has been avoided, and the necessary calculations have been made in as plain English as possible. A simple explanation has been given of the several kinds of companies and their management; of the mode of obtaining a policy, and the conditions upon which it is issued; of the manner of securing the amount due under a policy when it shall become a claim; of the various kinds of policies issued; of the construction and use of mortality tables; of net premium, expenses, and loading; of reserve for reinsurance, lapse and surrender of policies; of surplus, its distribution and modes of application; of government protection of policy-holders and supervision of companies. An outline sketch of the history of life assurance, particularly in the United States, has been added."

In the accomplishment of his task, Prof. Van Amringe has been, in our judgment, very successful; a large amount of information has been condensed into moderate space, and at the same time clearly set forth, while there is no attempt at mere display of learning or of research; though the treatise is the result of a good deal of both. The work is, as a whole, so well done that we omit any mention of the two or three minor points we had marked for criticism; excepting this one which the professor can readily amend in his next edition. Life *assurance* is scarcely known in this country. Life *insurance* is well known, and is the subject which Prof. Van Amringe has treated. The use of the word *insurance* is all but universal among American insurance men; and the distinction made in the use of the term, in the foot-note to page five of the pamphlet, is merely one of Babbage's crotchets.

We agree with President Barnard in saying that the general circulation of Prof. Van Amringe's pamphlet will "do much to inspire confidence among the people in the wisdom and safety of this mode" (life insurance) "of providing against the uncertainties of the future."

Statistical Atlas of the United States. Part III. Vital Statistics. By Francis A. Walker.

This is the first published installment of a series of maps and charts to comprise a "Statistical Atlas of the United States," designed to represent to the eye: 1. The physical features of the country; 2. The constituent elements and growth of population; 3. The vital statistics. The first and second parts will be published shortly. The third part, which is before us, comprises six maps and twelve charts. The maps, by variety of coloring, show the distribution of the statistical facts over the United States; while the charts, by a system of projected lines and shading, elaborate the details of the general idea, showing the facts as presented by States, sex, race, and age. For example: the first map shows the predomination of sex. Areas in which females predominate are left uncolored, while the remaining areas are colored deeply in proportion as the excess of males increases. The accompanying charts comprise a series of projections formed on the following principle: A vertical line, one inch long, is divided by horizontal lines into eight parts, representing as many decades. The angle to the left of the vertical line is supposed to represent males, and that to the right, females; and the shading of either angle indicates the predomination of the sex it stands for. Figures attached to the ends of the horizontal lines indicate by thousandths the number of individuals in each decade of life. The lowest horizontal line represents the first decade, and the length of each varies with the number of individuals in the decade it represents. In this way is shown the proportion between males and females in the aggregate population, the white, the colored, the foreign-born, etc., in the United States as a whole, and in severalty. The birth-rate, and the death-rate from consumption, malarial diseases, intestinal diseases, and fevers other than malarial, are represented in like manner. The statistics of blindness, deaf-mutism, insanity, and idiocy, are shown in charts only. An explanatory text, to accompany the maps, will soon be issued.

Building, Construction Timber, and Brick. By R. Scott Burn. New York: G. P. Putnam's Sons. 2 vols. 16mo, 135 pp. each. Price 75 cents per vol.

These little volumes aim at explanation of the technical terms used in building, and description of the parts they designate, entirely avoiding the larger subject of the principles upon which the art of building rests; or, more definitely, they explain what any part of a building is without telling how the building, as a whole, is constructed. The first takes up timber construction "as exemplified in the framing of floors, partitions, and roofs, explains the terms and describes the parts, and proceeds in the same manner with the subject as exemplified in doors, windows and internal fittings of houses," and with the lead and iron work connected therewith. The second similarly deals with the employment of brick, stone, slates, tile, etc., in building.

Each volume is accompanied by another volume of corresponding size, containing plates illustrative of the text.

Inorganic Chemistry. By Dr. W. B. Kemshead, F. R. A. S., F. G. S. New York: G. P. Putnam's Sons. 187 pp., 16mo. Price, 75 cents.

The aim of this book is the expression of primary principles, so as to be intelligible to beginners, while also serving as a text-book for more advanced students; and it answers this purpose very well. It begins by defining inorganic chemistry, enumerating the elements, stating the laws of affinity and combination and the principles of chemical nomenclature, and concludes with a description of the most important elements, and the combinations into which they enter.

ALCOHOL; ITS COMBINATIONS, ADULTERATIONS, AND PHYSICAL EFFECTS. By Colonel J. G. DUDLEY. New York: G. P. Putnam's Sons. 68 pages. 25 cents.

THIS useful pamphlet is a popular restatement of the chief facts and arguments derived from science, upon which the opponents of alcoholic beverages rest their case. For his motto, Colonel Dudley quotes the pithy observation of Dr. Willard Parker that "the laws of health are the laws of God, and as binding on man as the Decalogue;" and he then proceeds to show how the laws of health are violated by the use of spirituous drinks. The author does not profess to have made any new contributions to the question, but only to present the opinions of eminent authorities, who have given great attention to the subject. His pages present many startling facts suited to awaken serious reflection on the part of those who are in danger from the use of alcoholic beverages, but the freshest portion of the statement is his *exposé* of the outrageous system of cheating practised by the dealers in spirits. Of all the frauds of commerce, according to this writer, none will for a moment bear comparison with the adulterations and sophistications of intoxicating liquors. He gives recipes enough for the manufacture of all kinds of choice liquors to start a manufacturer in business, and shows, by the cheapness of the material used, how immensely profitable such a business must be. To the rising generation, who cannot have the benefit of the teachings of the old temperance campaign, such works as this of Colonel Dudley will prove valuable, and its wide circulation among them is to be strongly commended.

EPIDEMIC DELUSIONS. By FREDERIC R. MARVIN, M. D. New York: Asa K. Butts & Co. 28 pp., 12mo.

IN a lecture before the Liberal Club of New York City, the author endeavored to point out the causes of popular delusion in general. The lecture is here produced in book-form. Inherited tendencies to passion and ignorance in the masses, automatic action, sympathy, and the desire to imitate, are assigned as the causes. The cultivation of a healthy public sentiment is regarded as the only cure.

A RECORD OF EXPERIMENTS SHOWING THE CHARACTER AND POSITION OF NEUTRAL AXES. A Paper read before the American Society of Civil Engineers, by LOUIS NICKERSON, C. E.

THIS paper records a series of experiments undertaken to ascertain the character and position of neutral axes (unstrained parts) in beams and columns under pressure, and attempts to establish, as the result of such experiments, "that the neutral axis is a flexible line truly parallel to the top and bottom sides of the rectangular beam, and passing through the centres of gravity of its sections only when the load is evenly distributed from end to end; . . . but that, when there is a local pressure, the neutral axis is more or less governed in its direction and form by the strain passing from the point of local pressure to the point of support."

PAPERS CHIEFLY ANATOMICAL. Read before the American Association for the Advancement of Science, August, 1873, by BURT G. WILDER, M. D.

THESE are: Discussions of the Outer Cerebral Fissures of Mammalia, especially the Carnivora; Cerebral Variation in Domestic Dogs; Lateral Asymmetry in the Brain of a Double Human Monster, and Papillary Representation of two Arms in the Same; Habits and Parasites of Epeira Riparia; Need of a Uniform Position for Anatomical Figures; Lateral Position of the Vent in Amphioxus and in Certain Batrachian Larvæ; Composition of the Carpus in Dogs; Present Aspect of the Question of Intermembral Homologies; Variation in the Condition of the Sense-Organs in Fœtal Pigs of the Same Litter; Pectoral Muscles of Mammalia, and Variation of the same in Domestic Dogs. The papers are illustrated by numerous plates.

THE MECHANICAL PROPERTIES OF MATERIALS OF CONSTRUCTION. Read before the American Society of Civil Engineers, by Prof. R. H. THURSTON.

THIS is an attempt to formulate methods for determining the homogeneousness, elasticity, and cohesive power, of metallic substances, as well as the effects produced in them by shocks or blows, strains, and variations of temperature.

Bulletin of the Cornell University. Vol. i., Numbers 1 and 2.

Number 1 gives some account of the Morgan Expeditions under Ch. Fred Hartt to the Amazonas country in 1870–'71, and describes the geographical, topographical, and geological features of the Lower Tapajos, while Number 2 describes the Carboniferous Brachiopoda of Itaituba, on the river Tapajos.

Assaying by the Spectroscope.—This is a paper detailing experiments made in the United States Mint at Philadelphia, by Alexander E. Outerbridge, Jr., with a view of ascertaining the possibility of determining the value of metals by the spectroscope. The conclusion arrived at is, that assaying by this means is impracticable.

Transmission of Consumption. Read before the Maine Medical Association, June, 1874, by A. C. Hamlin, M. D.

The view taken is, that, by observance of natural law and judiçious selection in marriage, the ravages of this disease may be lessened; and the principal conclusions reached are, that persons of consumptive habits should not intermarry, and that consumptive mothers should not suckle their infants.

Contributions to the Geology and Physical Geography of the Lower Amazonas, by Ch. Fred Hartt; and The Devonian Brachiopoda of Ereré, by Richard Rathbun.

These two papers give some of the results of the Morgan Expeditions of 1870–'71 to the region named. The first is apparently a careful and elaborate description of the features of the Ereré-Monte-Alegre District and table-topped hills in Brazil, and of the formation of the strata composing the same. The second describes the fossil remains of molluscous animals discovered in the Devonian strata of that region.

Notes on the Mammals of Portions of Kansas, Colorado, Wyoming, and Utah. By J. A. Allen.

This is an enumeration of the families and species inhabiting those sections, and a description of their traits and habits.

The Reception of Dr. Gould.—In the year 1870 Dr. Benjamin A. Gould went to Cordoba, in the Argentine Republic, at the request of its Government, for the purpose of establishing a national Astronomical Observatory, and of making observations on the constellations of the southern heavens. His recent return to the United States was celebrated in Boston by a reception given to him on the 22d of June last. On that occasion he delivered an address, narrating the nature of his labors, the difficulties overcome, and the results achieved. The principal results are, the successful establishment of the observatory, the establishment of a national meteorological office and system of observatories throughout the republic, and the compilation of an atlas of the heavens from 10° north of the equator to the south pole, showing every star to the seventh magnitude inclusive.

Geographical Variation in North American Birds. By J. A. Allen.

This is a paper describing the variation produced in birds by differences of longitude and latitude. In differences of latitude variations occur in color, size, and details of structural parts, while in differences of longitude the variation is principally in color. These variations are in some cases so marked, that similar forms have been classed as separate species.

Transformations of the Common House-Fly. By A. S. Packard, Jr., M. D.

An interesting history of the changes incident to the life of this common insect. An individual lays about 120 eggs, usually in fresh horse-dung. The egg hatches in about twenty-four hours; the larva passes through three stages, occupying from five to seven days; the pupa state lasts about the same time; and, finally, the perfect fly appears at the end of ten to fourteen days from the time of hatching.

The Bench and Bar Review.—This is a new quarterly review, devoted to the interests of the legal profession, the publication of which was begun with the present year, in Baltimore. The leading articles in the first number are: "The Bar in England and France;" "The Civil Law: its Nature and Genius;" and "The Responsibility of Life Insurance Companies." It is adorned with a portrait of Caleb Cushing, and also contains a biographical sketch of him.

PUBLICATIONS RECEIVED.

Archives of Electrology and Neurology. Edited by George M. Beard, M. D. May, 1874. 143 pages. Issued semi-annually. Price, $2.50 a year.

The Germ Theory of Disease. By E. P. Hurd, M. D. 1874. 14 pages.

The Pathology of Inebriety. By Joseph Parrish, M. D. Baltimore, 1874. 17 pages.

Agriculture as a Pursuit. Address delivered before the Agricultural Class of the State University of Georgia, by E. M. Pendleton, M. D. 10 pages. Atlanta, 1873.

General Meeting of the American Social Science Association for 1874. 32 pages.

On the Value of High Powers in the Diagnosis of Blood-stains. By Joseph G. Richardson, M. D. 9 pages.

Introduction to General Biology. By Thomas C. McGinley. 12mo, 200 pages. Price, 75 cents. New York: G. P. Putnam's Sons.

New Method of treating Malignant Tumors. By George M. Beard, M. D. New York, 1874. 16 pages.

Check-List of Publications of the Smithsonian Institution. July, 1874. 24 pages.

Little Stories for Little People. By James Barron Hope. Price, 10 cents. 1874. 26 pages.

On the Atmosphere as a Vehicle of Sound. By Prof. John Tyndall. 1874. 60 pages.

On the Dissociation of Certain Compounds at Very Low Temperatures. By A. R. Leeds. 3 pages.

Rules of Evidence as applicable to the Credibility of History. By William Forsyth. London, 1874. 22 pages. Price, threepence.

Bulletin of the Minnesota Academy of Natural Sciences. 1874. 150 pages. Price, 50 cents.

The Compound Steam-Engine. By John Turnbull, Jr. New York: D. Van Nostrand & Co. 1874. 44 pages. Price, 50 cents.

Intellectual Culture. By Edward R. Palmer, M. D. Louisville, 1874. 20 pages.

The Protoplasm Theory. By Edward Curtis, M. D. New York, 1873. 23 pages.

Community of Diseases in Horses and other Animals. By W. Lauder Lindsay, M. D. 37 pages.

Review of Darwin on Expression. By Alexander Bain. London, 1873. 16 pages.

The Vermiculites, their Crystallographic and Chemical Relations to the Micas, etc. By Josiah P. Cooke, Jr. 1873. 32 pages.

Resources of Tennessee. By J. B. Killebren. Nashville, 1874. 8vo, 1193 pages.

Evidences of the Antiquity of Man. By James H. Whitmore. Rochester, 1874. 26 pages.

MISCELLANY.

Fritz Müller on Bee-Habits.—A letter to Mr. Darwin from Fritz Müller, dated Itaguahi, Brazil, April 20th, confirms many of the observations of Mr. Belt's remarkable work, "The Naturalist in Nicaragua," on the habits of ants. Further, he gives the following account of a contest between the queen-bee of a hive and the workers: A set of forty-seven cells had been filled, eight on a nearly-completed comb, thirty-five on an adjoining one, and four around the first cell of a new comb. When the queen had laid eggs in all the cells of the two older combs, she went several times round this circumference (as she always does, in order to ascertain whether she has not forgotten any cell), and then prepared to retreat into the lower part of the breeding-room. But, as she had overlooked the four cells of the new comb, the workers ran impatiently from this part to the queen, pushing her, in an odd manner, with their heads, as they did also other workers they met with. In consequence, the queen began again to go around on the two older combs; but, as she did not find any cell wanting an egg, she tried to descend, but everywhere she was pushed back by the workers. This contest lasted for a rather long while, till at last the queen escaped without having completed her work. Thus the workers knew how to advise the queen that something was as yet to be done, but they knew not how to show her where it had to be done. In the same hive there appeared to be two political parties among the workers, dissenting about the construction of the combs, one destroying what the other had begun to build.

The Western Grasshopper Plague.—A lady correspondent of a Western journal gives the most graphic description we have anywhere seen of the annoyance and discomfort caused by the grasshoppers during their recent invasion of some of the Western States and Territories. Writing from Northeastern Kansas, under date of August 5th, the correspondent states that then the grasshoppers were flying all around, and alighting on every thing, pelting against doors and windows as fast as hailstones ever came. It was scarcely possible to see through a screen door, on account of the insects swarming on the netting. Out-of-doors, the appearance was as though a severe snow-storm were raging, the wings of the flying grasshoppers looking white like flakes of snow. "They destroy every thing they alight on; every tree and shrub is covered with them. You know we read of Pharaoh's plague, where the insects got into the kneading-trough. I think this is one of them. I went out by the door to try and drive them off, and they flew all over me, and I had to change my dress to get rid of them. Instead of having rain, we are having showers of grasshoppers. Our six windows are completely covered with them, and as I write they are pouring down the chimney, and coming down the stove-pipe."

The Flora of the Black Hills.—General Custer, in a dispatch dated August 2d, graphically describes the botanical wonders of the Black Hills country, Dakota. Of "Floral Valley" he says that it surpasses in its display of flowers any public or private park he had ever seen. Every step of the march up that valley was amid flowers of the most exquisite colors and perfume. So luxuriant in growth were they that the troopers plucked them without dismounting. At one of the halting-places, General Forsyth plucked, choosing at random, seventeen beautiful flowers, of different species, and within a space of twenty feet square. The same evening, while seated at the mess-table, an officer called attention to the carpet of flowers under foot, and the question arose, how many different species could be plucked by the company without leaving their seats at table. Seven beautiful varieties were thus gathered. Prof. Donaldson, botanist of the expedition, estimated the number of flowers in bloom in Floral Valley at fifty, while an equal number of varieties had bloomed or were yet to bloom. The number of trees, shrubs, and grasses, was twenty-five, making the total flora of this valley embrace 125 species. Through this beautiful valley meanders a stream of crystal water, so cold as to render ice undesirable, even at noonday. The temperature of two of the many springs found flowing into it was ascertained to be 44° and 44½° respectively.

An International Pharmacopœia.—In the *American Journal of Pharmacy* for July 1st, Dr. Charles H. Thomas, of Philadelphia, calls attention to the serious disagreements existing between the British and United States Pharmacopœias; and strongly advocates the adoption of some measures by which the two books may be brought into greater accord, or, better still, fused into a single one. As they stand at present, the terms employed and the formulæ used are widely different, so that, while in the other departments of medicine what the student finds in the text-books and oral teaching of one country is common to both, in the department of materia medica, and in pharmacy, the variations and discrepancies could hardly be greater were it a case of two different languages. This condition of things operates as a great annoyance to the physician of one country wishing to practise in the other, and is still more aggravating to the teacher, who is unable to lay down any established rules of guidance beyond the limits of his own country, whereas these rules should be coextensive with the language.

Dr. Thomas thinks that the general adoption of the metrical, or some other uniform system of weights and measures, must precede the introduction of an international or universal pharmacopœia, but that we are now on a footing for establishing "a unity of standard for the composition of the principal preparations of the pharmacopœias of the English-speaking people, and this notwithstanding the radical differences between the systems of weights and measures in Great Britain and in this country respectively—the expedient needed to be adopted being no other than for the United States and British Pharmacopœial authorities to unite in putting into force the rule established by the Scandinavian nations, at their international convention, held in 1865, when the pharmacopœias of Norway, Sweden, and Denmark, were unified, and which rule is, to express the relative quantities used in pharmacy in proportional parts by weight, as, e. g., two parts by any system of weight of the first ingredient, four of the second, and one of the third, etc., thus securing like relative proportions in all standard compounds."

The Colorado Potato-Beetle.—Some time since Prof. Charles V. Riley predicted that the dreaded *Doryphora decem-lineata*, or Colorado potato-beetle, would reach the Atlantic States in 1878, the prediction being based on the average progress eastward of fifty miles per year. But latterly the movements of this pest appear to have been accelerated, for our esteemed contributor, Dr. Samuel Lockwood, has, during the past summer, found potato-vines infested with the larvæ of the genuine Colorado beetle in West Freehold, N. J. From a communication by Dr. Lockwood to the *Monmouth Democrat*, a copy of which, with several additional notes inserted, has been kindly furnished us by the author, we take the following account of the researches which led to the identification of the New Jersey brood with the formidable Western insect-pest. Having secured some specimens of the larvæ from West Freehold, Prof. Lockwood placed them in a glass jar with a quantity of potato-leaves. They fed ravenously on these for some time; symptoms of the pupa change were then observed, and, some friable earth having been furnished, the larvæ burrowed into it, and soon assumed the pupa form. In due time the perfect beetle appeared. But, as there are two species of *Doryphora* (*D. decem-lineata* and *D. juncta*), one of which, the *D. juncta* or bogus Colorado beetle, is common in the Atlantic States, and, as both are very much alike in the beetle-form, Dr. Lockwood took every precaution to avoid error in his diagnosis.

In the larva stage the difference between the two species is decisive. Larvæ of the "bogus bug" have on each side the body a row of distinct, round, black spots, while larvæ of the true Colorado species have two rows of these spots on each side of the body. To make assurance doubly sure, Dr. Lockwood procured eggs from the beetles he had himself raised, and had larvæ hatched from them. There was now no room for doubt, for every one of them had the double row of spots. This conclusion is concurred in by Prof. C. V. Riley.

The capacity of the Colorado beetle for reproduction is amazing. They bear three broods in one season: one female has been known to lay 1,200 eggs. Says the Canadian *Entomologist:* "If the progeny of a single pair were allowed to increase without molestation for one season, the result would amount to over 60,000,000."

In anticipation of this insect reaching Europe from our Atlantic States, the German Government has made thorough preparation to meet it. Prussia has adopted a system of traveling lecturers on agriculture, *Wanderlehrer*. Each *Wanderlehrer* has a district of twenty or thirty miles, and his duties are to visit the farmers personally and instruct them. Specimens of the Colorado beetle have been supplied to these teachers, so that, through their instructions, the German farmers are already well informed as to this insect, in fact, know all about it, and can recognize it when it comes. If such a thing is possible, it will be destroyed on its first appearance.

The original home of this insect was Colorado. It is known that it lived upon the mountains there over fifty years ago, and that it fed upon the *Solanum rostratum*, a species of wild-potato. When the white man began planting potato-patches on the Rocky Mountains, better food, and in larger quantities, caused the great increase of the insect, which immediately began spreading toward the East. In 1859 it had reached within a hundred miles of Omaha. In 1861 it had entered Iowa, and in 1865 had crossed the Mississippi into Illinois. Thus on it moved eastward, generally at about fifty miles a year, though latterly the movement must have been more rapid. The sad thing is, that every swarm that moves leaves a permanent colony behind.

Every device has been employed to destroy them. Paris-green has been dusted on the plants. This will kill all it touches. But its application is expensive, and not without danger. It was found necessary to use an ingenious machine drawn by two horses. This consisted of a large box supported by wheels. The box was open at the top, over which was a revolving flapper, or fan, that brushed the vines over the box, at the same time striking them, thus causing the beetles to fall to the bottom of the box, where was a pair of revolving rollers, between which they were crushed. There were other kinds of machines, but this was the most effective.

The Colorado beetle is about half an inch long, roundish, and in form much like a lady-bug. It has a series of ten stripes on each wing-cover, being alternately brown and yellow. It is a very beautiful insect; but, alas! it is among the most formidable of those diminutive enemies of the industry of man, whose depredations, even in the brief history of our nation, has cost us, in money loss of crops, more by many times than the sum-total of all our wars. Already, in Maryland, the ravages of the new-comer are filling the farmers with dismay.

Prof. Morse on the North American Unionidæ.—In his paper on this subject, at the recent meeting of the American Association, Prof. Morse explained, on the theory of natural selection, why the fresh-water mussels are so much more abundant in this country than in Europe, and why they are so much more numerous west of the Alleghanies than on their eastern slope. The families of fresh-water mollusks are few in number, and are intimately related with those families in the sea that have proved capable of surviving admixture with fresh water, and that commonly occur between high and low water mark. Many animals have adapted themselves to the changing influences which are liable to occur between high and low water mark, such as inundations, fresh water, and rain. Others have adapted themselves to brackish water, and, to those forms that have survived, the fresh-water mollusks are closely related. In this struggle for adaptation to new conditions, great modification of form takes place, a fact illustrated and confirmed by what has been observed in the case of the mya or common clam. This belongs between high and low water, and, although never yet so far changed as to live in fresh water, it has passed through almost innumerable modifications of form before giving up the struggle. Now, referring to the past geological history of this continent, we find, from the successive upheavals of the Laurentian hills to the North, the Alleghanies on the East, and the Sierras on the West, a gradual inclosing of wide inland seas, lagoons, whose drainage must have been toward the Mississippi Valley. These, in their gradual transition from briny to fresh water, would furnish all the conditions favorable to a transformation from marine to fresh water species; to be followed by an infinite number of fresh-water forms, according as the subsequent conditions varied.

Use of the Actual Cautery.—The "actual cautery" is commonly defined to be a *red-hot* iron used for burning or disorganizing the parts to which it is applied. The application of a red-hot iron directly to the living tissues is justly regarded as an extremely painful operation; but, if the iron be heated to a *white heat*, it is absolutely painless. The difference between the two is analogous to the difference between a bullet speeding at its maximum velocity, which may produce mortal injury without pain, and a nearly-spent bullet, which slowly lacerates the tissues and causes agony. Dr. J. S. Camden, writing in the *Medical Times and Gazette*, recites as follows his own experience with cauteries at different degrees of heat: "When actual cautery," says he, "is to be used, the iron must be heated till it is really of a white heat, and looks almost as white as white paper. If then applied it destroys the part instantaneously, giving no pain; but it must be removed quickly on the heat decreasing, and then another iron employed. If a red-hot iron only is used, the agony is intense. The first time I saw the cautery used, on a girl of fourteen years, no pain was given; the second time, on an elderly person (both for fungus in the upper maxillary bone) her screeching was fearful, till I told the operator his irons were not half hot enough. He requested me to heat them properly, which being done, not a murmur was heard. The last time was opening four or five sinuses in a horse's shoulder. He never flinched and scarcely seemed aware of what was being done. I would suggest using—to obtain the white heat for actual cautery—a large spirit blow-pipe."

An Edible Lizard.—Dr. Burt G. Wilder communicates to the *American Naturalist* a brief note on the *Menobranchus maculatus* as an article of food. This animal he regards as probably a variety of the banded Proteus, or big water-lizard, but it is never striped, and always spotted. So abundant are they in Cayuga Lake that a single fisherman brought him a hundred of them during the month of March. The animal is held to be poisonous, and the fishermen dislike even to touch them. So far, however, is this from being the case, that they are absolutely harmless in every way. Dr. Wilder and his associate, Dr. Barnard, have eaten one which was cooked, and found it excellent. It is their intention to recommend the *Menobranchus* for food, but not until all their investigations into the anatomy and embryology of the animal are concluded.

Conversion of Wood into Lignite.—In one of the old mines of the Upper Hartz, in Hanover, some of the wood originally employed in timbering has become so far altered as to assume most of the characters of a new lignite, or brown coal. Many of the levels in the ancient workings of this mine are filled with refuse matter, consisting chiefly of fragments of clay-slate, more or less saturated with mine-water, and containing here and there fragments of the old timbering. When wet, this wood is of a leathery consistence, but in the air it soon hardens, having most if not all the characters of lignite. It breaks with a conchoidal fracture, and the parts that are most altered have the black, lustrous appearance of the German "pitch coals." Chemical examination shows that this altered wood is nearer to true coal than some of the younger tertiary lignites. From all this it would appear that the transformation of vegetable matter into coal requires less time than is usually estimated by geologists; in the present instance it cannot have been over four centuries.

Indictment of the English Sparrows.—In his "Key to North-American Birds," Mr. Coues expressed his apprehensions that the English sparrow would molest and drive away our native species. He now writes to the *American Naturalist* that these apprehensions have already been verified. From a letter written by Mr. Thomas G. Gentry, it appears that, in the neighborhood of Germantown, Pa., the English sparrows are driving away the robins, blue-birds, and native sparrows. "They increase so rapidly, and are so pugnacious, that our smaller native birds are compelled to seek quarters elsewhere." It is chiefly on this account that Mr. Coues has always been opposed to the introduction of the English sparrow, but also for other reasons. He holds that there is no occasion for them in this country, and that the good they do in destroying certain insects has been overrated. The time will come, he says, when it will be deemed advisable to take measures to get rid of these birds, or at least to check their increase.

Anatomy of the Porpoise.—Mr. Frank Buckland, having dissected a porpoise, gives some interesting information on the structure of that animal. In the matter of bowels it is well provided for, the specimen examined having 62 feet 2 inches of intestine. The stomach was so complicated that it could not be made out by ordinary dissection. To get round the difficulty, Mr. Buckland hung it up by the œsophagus, and filled it with plaster of Paris, of which nearly a pailful was required before the organ was fully distended. It was then found that the porpoise has two stomachs—one in which the prey is kept, and the other in which it is digested. A careful section of the head showed the blow-hole to be a most complicated mechanism. The porpoise, being a pure mammal, has a four-cavitied heart, and a pair of lungs. Now, Nature has ordained that he shall live in the sea; the problem is, how to keep water out of the lungs. In the first place, his nose is guarded by a valve placed on top of his head, and when the porpoise breathes he comes to the surface, and takes a deep inspiration. Not a drop of water ever gets in. But how does he work his valve, and keep the water out of his lungs, when he is asleep? The answer to this question cannot be given yet. Mr. Buckland intends to study the subject when next he has a live porpoise at the Brighton Aquarium.

Reproduction of Ancient Colors.—A remarkable and very beautiful shade of blue is noticeable upon many of the ornaments found in the tombs of Egypt. Analysis, some time since, proved the color to be formed by a combination of soda, sand, and lime, with certain proportions of copper. From these substances the ancient Egyptians obtained three different products: first, a peculiar kind of red, green, and blue glass; second, a brilliant enamel; and lastly, this blue color, which was used for painting. By synthetic experiments, Peligot has succeeded in reproducing this peculiar shade of blue, by heating together seventy-three parts of silica, with sixteen of oxide of copper, eight of lime, and three of soda. The temperature should not exceed 800° Fahr., as, in such case, a valueless black product is the result.

Prof. Huxley on Female Education.—A lady, Miss Sophia Jex-Blake, having failed to pass successfully an examination at the Edinburgh University, brought the charge of unfairness against the examining board. One of the lady's papers, that on natural history, having been submitted to Prof. Huxley for his opinion, he expressed his full concurrence in the decision of the board, so far as this paper was concerned. In a letter to the *Times*, giving a history of the affair, Prof. Huxley remarks as follows on the question of woman's education: "Without seeing any reason to believe that women are, on the average, so strong physically, intellectually, or morally, as men, I cannot shut my eyes to the obvious fact that many women are much better endowed in all these respects than many men, and I am at a loss to understand on what grounds of justice or public policy a career which is open to the weakest and most foolish of the male sex should be forcibly closed to women of vigor and capacity. We have heard a great deal lately about the physical disabilities of women. Some of these alleged impediments, no doubt, are really inherent in their organization, but nine-tenths of them are artificial—the product of their mode of life. I believe that nothing would tend so effectually to get rid of these creations of idleness, weariness, and that 'over-stimulation of the emotions,' which, in plainer-spoken days, used to be called wantonness, than a fair share of healthy work, directed toward a definite object, combined with an equally fair share of healthy play, during the years of adolescence; and those who are best acquainted with the acquirements of an average medical practitioner, will find it hardest to believe that the attempt to reach that standard is likely to prove exhausting to an ordinarily intelligent and well-educated young woman."

Do Dogs perspire?—It is frequently urged, as an argument against the ordinary method of muzzling dogs, that it closes the mouth, and thereby prevents perspiration, which, in the dog, is said to take place only through the mouth. This, according to *Land and Water*, is an error; perspiration going on through the skin, as in other animals. The idea of perspiratory glands in the tongue is characterized as absurd, these organs being only found in the dog's skin, which is abundantly supplied with them. The real cruelty of the close or strap muzzle is, that it hinders free *respiration*, rather than free perspiration.

New Species by Sudden Variations.—A paper was read by Mr. Meehan, at the American Association, entitled "Change by Gradual Modification not the Universal Law," in which, after recounting a large number of facts in botany which go to show that varieties and new species are not always the result of imperceptible gradations, but, on the contrary, may be produced at a single leap, the author draws the following conclusions:

1. Morphological changes in individual plants are not always by gradual modifications. 2. Variations from specific forms follow the same law. 3. Variations are often sudden, and also of such decided character as to seem generic. 4. These sudden formations perpetuate themselves similarly in all respects to forms springing from gradual modifications. 5. Variations of similar character occur in widely-separated localities. 6. Variations occur in communities of plants simultaneously by conditions affecting nutrition, and perhaps by other causes. From these premises Mr. Meehan argues that new and widely-distinct species may be suddenly evolved from preëxisting forms without the intervention of natural selection, and, of course, without the existence of connecting links.

Many who heard this paper were at first disposed to consider it an attack on Darwinism, its tendency being to lessen the importance of the principle of natural selection. But its discussion showed that such was not the view of those best able to judge; Profs. Morse, Riley, Gill, Gray, and even Mr. Meehan himself, regarded the argument as a contribution to the theory of evolution, while all but the author were of the opinion that it was quite consistent with the principle of natural selection, and, indeed, had already been taken into the account by Mr. Darwin.

Nitrogen of the Soil.—Prof. H. B. Armsby read at the American Association meeting a paper on the "Nitrogen of the Soil," in which, after stating that no plant has the power, so far as we know, of taking its nitrogenous materials directly from the atmosphere, he investigates the sources from which the nitrogen of plants is derived. Nitrogenous organic substances, such as exist in freshly-manured soils, may yield free nitrogen by decomposition, though the particulars of the process are as yet not fully ascertained. Under some circumstances these organic substances are capable of causing free nitrogen so to enter into combination with them as to increase their nitrogenous contents. This increase has generally been attributed to the formation of nitric acid from free nitrogen by oxidation. The author made a series of experiments on the loss and gain of nitrogen, his method being to allow organic matter containing a known amount of nitrogen to decay, under circumstances allowing measurement of the nitrogen given off or accumulated. The organic matter consisted of dried and sifted barn-yard manure, mixed with one-quarter its weight of dried and pulverized flesh. There were eight experiments in all, four of which were conducted in purified air, and four in purified nitrogen. The quantities and materials used for the two series of experiments were as follows:

No. of Experiments.	Organic Matter.	Gypsum.	Potash.	Water.	Total Nitrogen.
	Grammes.	Grammes.	Grammes.	Cubic centimetres.	Grammes.
I.					
1	15	..	....	6	0.486
2	15	..	0.798	6	0.486
3	15	15	....	6	0.486
4	15	15	0.798	6	0.486
II.					
1	15	..	....	6	0.453
2	15	..	0.798	6	0.453
3	15	15	....	6	0.453
4	15	15	0.798	6	0.453

The result of the experiments shows a loss of nitrogen in Nos. 1, 3, and 4 of Series I., amounting to 11.11, 6.21, and 13.09 per cent. respectively; and in Nos. 3 and 4, of Series II., of 1.14 and 1.94 per cent. No. 2, of Series I., shows a gain of 15.22 per cent.; and Nos. 1 and 2, of Series II., a gain of 1.48 and 19.34 per cent. respectively. The author's conclusions are: 1. The loss of free nitrogen during the decomposition of nitrogenous organic matter is generally due to oxidizing action. 2. An increase of combined nitrogen in soil may take place by oxidation of free nitrogen to nitric acid. 3. Some organic substances in the presence of a caustic alkali are able to fix free nitrogen without the agency of oxygen, or the formation of nitric acid.

Tea-Production in Bengal, British India.—In the entire presidency about 800,000 acres are "held for purposes connected with the tea-industry." Of this only about 70,000 acres are occupied with tea-plants in bearing. This portion is subdivided into "mature-plant land" and "immature-plant land." The average yield of the mature-plant land is about 237 pounds per acre; that of the immature, about 80 pounds; of the whole, 208 pounds per acre. The total production is about 15,000,000 pounds.

NOTES.

Prof. Ch. Fred Hartt, of Cornell University, sailed on the 5th inst. on his fifth expedition to Brazil, accompanied by one of his students, W. J. C. Brauner. He proposes to make a reconnoissance of the gold and diamond region north of Rio de Janeiro, and explore carefully several rich paleontological and archæological localities discovered on previous expeditions. It is his intention at the same time to review his studies on the Southern Glacial Drift.

The entomologists of the American Association for the Advancement of Science have formed a special organization, to be known as the "Entomological Club of the American Association for the Advancement of Science," with Dr. John L. Le Conte as President, and C. F. Riley as Secretary. The Club will annually assemble one day in advance of the Association meeting, and hold other meetings during the session of that body. The objects, as stated by the *Tribune*, are the exchange and exhibition of specimens, and especially of types of such species as may have been described during the preceding year.

The largest tree in Ohio stands in the Methodist parsonage-lot, Chillicothe. It is an elm, nearly eight feet in diameter, and 110 feet across the branches. Its height is not above 50 feet. The trunk is hollow, and has been so for many years. It is supposed to be four or five hundred years old.

Borelly, of Marseilles, on the 26th of July, discovered a new comet. Prof. Swift, of Rochester, who was the first in this country to observe this comet, describes it (July 30th) as being quite large and bright for a telescopic comet. It has a strong central condensation, but no apparent nucleus or tail. It is in the fourth coil of Draco, and moves at the rate of about a degree per day.

Gold and platinum have been drawn to a "spider-line" for the field of a telescope, by coating the metal with silver, drawing it down to the finest number, and then removing the coating by acid, leaving the almost imperceptible interior wire, which, in an experiment made in London, was so attenuated that a mile's length weighed only a grain.

A correspondent of *Land and Water* gives the following instance of canine sagacity: A canary-bird having escaped from its cage, a cat in the room was seen gazing intently at some object under a chair. There lay a favorite terrier, with the canary firmly yet tenderly grasped in its mouth, all the while watching the cat, evidently with the object of keeping the latter at a safe distance from the bird. On being asked for the bird, the terrier instantly gave it up. It had received no injury whatever. How long the dog may have protected the poor little bird is not known, but the circumstance is at all events a notable instance of what is usually described as sagacity, but which may be more justly termed reason in the dog.

The extraordinary drought of the past summer in Europe had a disastrous effect on the fishes. Near Asnières on the Seine, shoals of fish of all sizes lay on the surface of the water as if half dead or stupefied. A somewhat similar state of things appeared in the vicinity of Oxford, where fish of all sorts and sizes were picked up dead in the shallows. In many parts of Ireland the trout in the smaller streams have been nearly destroyed. The trouble at Asnières and at Oxford was no doubt the result of the poisoning of the Seine and the Isis by sewage.

A pipe is now being laid for the conveyance of petroleum from the oil-wells of Millerstown, Pa., to the Baltimore & Ohio Railroad, a distance of 40 miles. The pipe is three inches in diameter, and its capacity 4,000 barrels per day.

The Railroad Commissioners of Massachusetts have held a hearing on the subject of steam-whistles on railroads, and have recommended that they should be restricted in use to "cases of danger and the necessary management of freight-trains."

At the end of July the amount of money contributed so far to the Agassiz Memorial Fund was $7,800.

The sum of $1,000 has been deposited with the Franklin Institute by Uriah A. Boyden, of Boston, to be awarded as a premium to "any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity." The memoirs, which are to describe in detail the apparatus, mode of experimenting, and results, are to be sent in to the secretary of the Institute by January 1, 1875.

At the Priestley Centennial Meeting, Prof. Fraser urged the formation of a Chemical Society, to be independent of the American Association for the Advancement of Science, but the project was rejected. Dr.

H. C. Bolton's amendment was approved, appointing a committee of five to coöperate with the American Association at the August meeting, to establish the chemical section of that body on a firmer basis.

MONUMENTS to Liebig are to be erected both at Munich and at Giessen. At the Chemical Centennial, Prof. J. Lawrence Smith urged the raising of a subscription for these memorials among the chemists of the United States. The following subscriptions were announced, it being understood that they are to be devoted to the monument at Giessen: Prof. J. L. Smith and Prof. Silliman, $200 each; Prof. Horsford, $100; Prof. Chandler and Dr. Amend, $50 each.

THE Signal-Office at Washington has perfected arrangements with the various meteorological bureaus of European states, for an international exchange of weather reports. This coöperation cannot fail to be productive of highly-important results both for commerce and for science.

A COMMISSION of Icelanders is about to visit Alaska, to inquire into the prospects for the settlement of a colony of their countrymen in that Territory.

IN a letter dated Tokei, Japan, May 18th, and addressed to Prof. Joseph Henry, Prof. Henry S. Monroe says that carboniferous coal of the best quality has been discovered on the island of Yesso, in the tertiary formation; it is true bituminous coal. "So far as I know," says Prof. Monroe, "this is the first time that such perfect fuels have been found having so recent an origin as the Tertiary age."

THE cities of Lyons and Versailles on the one hand, and Paris on the other, have always differed very widely in the extent to which they have been ravaged by cholera. Paris falls an easy prey to the epidemic, while it has never gained a firm foothold in either Lyons or Versailles. M. Decaisne finds an explanation of this in the different characters of the soil underlying the three towns. Versailles is built on a bed of clay, impervious to water; Lyons stands upon granite; while Paris rests upon a porous foundation. M. Decaisne does not attribute the presence and absence of cholera to these facts alone, but his arguments are directed to show that they may exert a powerful influence.

A NOTE in the *American Chemist* by Mr. J. M. Merrick shows how some wines may easily be freed of their excess of acid, without in the least impairing their flavor. In the autumn of 1871, Mr. Merrick made from Concord grapes 120 gallons of wine, adding 1½ lb. of sugar to each gallon of juice. By analysis made June, 1873, this wine contained 17.5 per cent. alcohol, but it was undrinkably sour. Analysis showed it to contain a little more than *one per cent.* of free acid, mainly tartaric. In September about seven pounds of neutral tartrate of potassa was added, with gratifying results: the color of the wine was lightened, and its hardness and sourness diminished. Into a gallon of another harsh, crude, and unpalatable wine, the author introduced a trifling amount of neutral tartrate of potassa, and by heating the wine to about 50° C. it became mild, and high flavored, without unpleasant acidity.

M. DUMAS has communicated to the French Academy of Sciences some experiments by Messrs. Troost and Hautefeuille on the hydrates of mercury or combinations of hydrogen with that metal. These combinations, it is said, so strongly resemble those which constitute the amalgams of mercury with silver and other white metals, that it is hardly possible to doubt that they are themselves amalgams, and hence that hydrogen is a metal, a fact apparently indicated in many other analogies.

MR. A. ENGELMANN, in the *Engineering and Mining Journal*, shows that rope tramways are no recent inventions, citing a figure of such a tramway, in a work dating from 1766. It is there stated that many years before, the Bishop's Mound at Dantzic was leveled by means of this machine, and carried across river, fields, gardens, and pastures. The drawing shows an endless rope passed over a roller attached to the side of upright posts, and at the extremities of the line over horse-whims; buckets are attached to it by thin ropes, spliced to the main rope. At each roller a rod is attached to a piece of the post, which, bending upward and outward round the roller, pushes the bucket-rope aside, and enables the bucket to pass by the rollers.

A PROFESSORSHIP of Textile Industries has been founded in connection with the Yorkshire College of Science, by the "Worshipful Company of Clothworkers." The incumbent of the new chair willl be required to have a practical knowledge of all materials used in the woollen and worsted manufactures; to be able to give practical instruction in every branch of weaving; to apply the laws of color to the production of colored designs; to explain and illustrate the processes of carding, combing, and spinning—in short, to be perfectly familiar with every aspect of textile industry.

THE *Lancet* "entirely and heartily" adheres to the principles and practice of cremation as set forth by Sir Henry Thompson. "Custom and sentiment," says the *Lancet*, "will prove formidable opponents to this reform; but all reforms meet with keen opposition, notably those connected in any way with the public health. If this question, however, be viewed in a purely sanitary aspect, the arguments in favor of cremation are almost irresistible, and those who work at preventive medicine should add it to their code of subjects, and urge it continuously on the attention of the public."

The most unhealthy city in Europe is Berlin. According to the *Lancet*, its death-rate amounts to 5.5 per cent. Munich comes next after Berlin. These figures speak ill for sanitary science in the German Empire.

A dispatch from the Washington Naval Observatory, dated August 10th, states that Prof. Newcomb has completed the approximate elements of Borelly's comet. It would pass its perihelion about August 25th, and would be visible with a telescope in the evening till about the end of the month, and in the morning during the whole of September, but would never be visible to the naked eye. The orbit, as determined by Newcomb, indicates that it is a new comet.

The practice of dyeing Easter eggs first led to the discovery of the value of albumen as a mordant.

Two expeditions are projected to set out from Archangel: the one to explore the traces of ancient glaciers in Russian Lapland; the other is to make zoological explorations of the littoral of the White Sea. Dr. Yarjinsky, who lately explored this region, found in the White Sea and the Arctic Ocean species of fishes and crustaceans entirely unknown hitherto.

To determine the action of coal-gas on plants, J. Boehm placed the ends of willow cuttings in flasks containing a little water and filled with coal-gas: the cuttings developed only short roots, and the buds on the upper parts died soon after unfolding. Again, of ten plants in pots, with access of gas to the roots, seven died in four months. In all these cases the gas acts indirectly, poisoning the soil, and through the soil the plant.

A writer in the *Chemical News* calls attention to a source of error in mercurial thermometers, which does not appear to be generally known. His thermometer having been placed in a Wurtz tube, so that the column of mercury was entirely surrounded by the vapor of a distilling liquid, was, after some days, noticed to indicate three degrees too little. The discrepancy was found to have been caused by volatilization of the upper surface of the mercury and condensation on the upper part of the tube. By causing the mercury to flow to the end of the tube and back, the condensed portion was gathered up, and the correct temperature indicated.

A lunar rainbow of unusual brilliancy was recently seen by Mr. Charles W. Cottel, of Wilmington, Ill. It appeared about eleven o'clock on the evening of July 26th. The moon was nearly full, and almost due south; a light rain-cloud passed in a northwesterly direction: soon the moon was unobscured, and the conditions were the best for the observation of the phenomenon. A perfect bow was seen in the passing cloud, its apex having an elevation of about 40°. The bow continued visible for some twenty minutes. Much to his regret, Mr. Cottel was riding alone, and was unable to have his impressions of color verified by better eyes (his own in that respect being unreliable from disease); but to his vision the bands of orange and indigo were plainly distinguishable.

One of the precepts of the Law of the Twelve Tables, the most ancient code of the Romans, forbids the burying or burning of dead bodies within the limits of the city. It was but the other day, as it were, that this simple dictate of sanitary prudence came to be recognized among the moderns.

English physicians are not allowed to practise their profession in the republic of Chili, without undergoing an examination in medical science, conducted in the Spanish language. The Chilians pretend to an excellent and wide-spread knowledge in medicine not attained by other nations, and they deny that English doctors are equal to their standard.

From Joubert's researches on phosphorescence, it appears that this property is possessed by arsenic and sulphur under certain conditions, viz., when subjected to a temperature of 200° C. and high pressure.

A curious phenomenon was observed by M. Tresca, on hammering the bar of platinized iridium recently prepared for the International Metric Commission. At each stroke there were produced rectilinear luminous flashes, which crossed each other in the form of an X, extending from one side of the bar to the other, and always in the same manner. No explanation is offered of the phenomenon.

A sort of flute, dating from the age of polished stone, has been found by E. Piette in a layer of charcoal and cinders, in the cavern of Gourdan, Haute-Garonne, associated with flint implements of neolithic types. The instrument is of bone, and pierced with two well-made holes. This is the first discovery on record of a musical instrument belonging to prehistoric man.

The Forty-seventh Congress of German Physicians and Naturalists will assemble at Breslau on September 18th, the sittings to continue till the 24th.

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