THURSDAY, OCTOBER 13, 1881

MR. DARWIN ON THE WORK OF WORMS

The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits. By Charles Darwin, LL.D., F.R.S. (London: John Murray, 1881.)

IF the world were not already accustomed to the unprecedented fertility of Mr. Darwin's genius, it might well be disposed to marvel at the appearance of yet another work, now added to the magnificent array of those which bear his name. But feelings of wonder at Mr. Darwin's activity have long ago been sated, and most of us have grown to regard his powers of research as belonging to a class *sui generis*, to which the ordinary measures of working capacity do not apply. Be our feelings of wonder, however, what they may, it is most gratifying to find that this latest work from the hand of our illustrious countryman is in every way worthy of its predecessors. Everywhere throughout the book we meet with the distinctive attributes of Mr. Darwin's mind. Beginning with matters of the most common knowledge, which at first sight appear to furnish the most unpromising material, he proceeds by close observation of details and sagacious manipulation of facts to establish general truths of the most far-reaching importance in directions where we should least have expected any such truths to lie.

But to avoid the presumption of seeming to commend the work of so great a master, we shall proceed at once to render an epitome of the work itself. This, as its title is sufficient to denote, is an extension of the celebrated paper "On the Formation of Mould," read before the Geological Society in 1837 (See *Trans.* Geol. Soc. vol. v. p. 505); but the extension is so considerable that the present volume is really a new work. The subject, of course, is the same; but the later observations, while tending to confirm, and in fact to demonstrate, the conclusions based upon the former, have served to swell a short paper into a book of over 300 pages. Alluding to this paper, Mr. Darwin writes:

"It was there shown that small fragments of burnt marl, cinders, &c., which had been thickly strewed over the surface of several meadows, were found after a few years lying at a depth of some inches beneath the turf, but still forming a layer. This apparent sinking of superficial bodies is due, as was first suggested to me by Mr. Wedgwood, of Maer Hall, in Staffordshire, to the large quantity of fine earth continually brought up to the surface by worms in the form of castings. These castings are sooner or later spread out, and cover up any object left on the surface. I was thus led to conclude that all the vegetable mould over the whole country has passed many times through the intestinal canal of worms. Hence the term 'animal mould' would be more appropriate than that commonly used of 'vegetable mould.'"

Dealing next with criticisms which from time to time have been made upon his original paper, Mr. Darwin quotes one from Mr. Fish, which we may here re-quote on account of its instructive character. "Considering their weakness and their size, the work they are represented to have accomplished is stupendous." On which Mr. Darwin observes:—"Here we have an instance of that inability to sum up the effects of a continually recurring cause, which has often retarded the progress of science, as formerly in the case of geology, and more recently in that of the principle of evolution." He then adds:—

"Although these several objections seemed to me to have no weight, yet I resolved to make more observations of the same kind as those published, and to attack the problem on another side; namely, to weigh all the castings thrown up within a given time in a measured space, instead of ascertaining the rate at which objects left on the surface were buried by worms. But some of my observations have been rendered almost superfluous by an admirable paper by Von Hensen, already alluded to, which appeared in 1877. Before entering on details with respect to the castings, it will be advisable to give some account of the habits of worms from my own observations and from those of other naturalists."

Of these habits the most interesting are as follows:—

Although earth-worms are properly speaking terrestrial animals, they are still "like the other members of the great class of annelids to which they belong," semi-aquatic. For while dry air is quickly fatal to them, they may live when completely submerged in water for nearly four months. Normally they live in burrows, and generally lie motionless just at the mouth of the latter, so that by looking down into the burrows the heads of the worms can be seen. This habit of lying near the surface leads to their destruction in enormous numbers by birds. For,

"Every morning during certain seasons of the year, the thrushes and blackbirds on all the lawns throughout the country draw out of their holes an astonishing number of worms; and this they could not do unless they lay close to the surface. It is not probable that worms behave in this manner for the sake of breathing fresh air, for we have seen that they can live for a long time under water. I believe that they lie near the surface for the sake of warmth, especially in the morning; and we shall hereafter find that they often coat the mouths of their burrows with leaves, apparently to prevent their bodies from coming into close contact with the cold damp earth. It is said that they completely close their burrows during the winter."

As regards powers of special sense, it has been observed by Hoffmeister that, although destitute of eyes, earthwarms are sensitive to light, time however being required for the summation of the stimulus before it is responded to. It is only the anterior extremity of the body, where the cerebral ganglia are situated, that is thus sensitive to light. These observations have been confirmed by Mr. Darwin. He further found that the colour of the light apparently made no difference in the result, nor did partly filtering out the heat-rays by means of a sheet of glass; while a dull-red heated poker, held at such a distance from the worms as would cause a sensible degree of warmth to the hand, did not disturb them nearly so much as the light from a candle concentrated by a lens. The sensitiveness to light is less when a worm is engaged in eating or in dragging leaves into its burrow—a fact which Mr. Darwin is disposed to consider analogous to what in higher animals we know as the distracting influence of attention. When not engaged in any active operation, the sensitiveness of worms to light is so considerable that "when a worm is suddenly illuminated it dashes like a rabbit into its burrow."

With respect to hearing, all the experiments went to show that worms are totally deaf to all kinds of aërial vibration, although extremely sensitive to the vibration of any solid object with which they may be in contact, as was shown, among other ways, by placing flower-pots containing worms in their burrows upon a piano; on striking single notes, whether high or low, the worms instantly retreated. In this connection, also, the following may be quoted:—

"It has often been said that if the ground is beaten or otherwise made to tremble, worms believe that they are pursued by a mole, and leave their burrows. I beat the ground in many places where worms abounded, but not one emerged. When, however, the ground is dug with a fork and is violently disturbed beneath a worm, it will often crawl quickly out of its burrow."

Regarding smell, the interesting result was obtained, that the sense is "confined to the perception of certain odours"—namely, those emitted by natural food. For while the animals showed themselves indifferent to tobacco juice, paraffin, &c., held near them, pieces of cabbage-leaf, onions, &c., when buried near an earthworm, were always discovered by the animal.

The presence of taste was proved by the fact that the worm showed a preference for some varieties of cabbage over others; but "of all their senses, that of touch, including in the term the perception of vibration, seems much the most highly developed."

Worms are omnivorous, dragging pieces of meat as well as leaves into their burrows for the purpose of eating them. They smear the leaves so drawn in with a secreted fluid. This fluid is alkaline, and acts both on the starch granules and on the protoplasmic contents of the cells; it thus resembles in nature the pancreatic secretion, and serves partly to digest the leaves before they are taken into the alimentary canal—so constituting the only case of extra-stomachal digestion hitherto recorded in an animal—its nearest analogy being perhaps that of the digestive fluid of Drosera or Dionœa, "for here animal matter is digested and converted into peptone not within a stomach, but on the surface of the leaves."

We now come to one of the most interesting chapters, which deals with the habit of dragging down leaves, &c., into the burrows; for here the experiments elicited some very remarkable evidence of action which is apparently intelligent. These experiments are thus led up to.

"Worms seize leaves and other objects, not only to serve as food, but for plugging up the mouths of their burrows; and this is one of their strongest instincts. Leaves and petioles of many kinds, some flower-peduncles, often decayed twigs of trees, bits of paper, feathers, tufts of wool and horse-hairs are dragged into their burrows for this purpose. . . . When worms cannot obtain leaves, petioles, sticks, &c., with which to plug up the mouths of their burrows, they often protect them by little heaps of stones; and such heaps of smooth rounded pebbles may frequently be seen on gravel-walks. Here there can be no question about food. A lady, who was interested in the habits of worms, removed the little heaps of stones from the mouths of several burrows and cleared the surface of the ground for some inches all round. She went out on the following night with a lantern, and saw the worms with their tails fixed in their burrows, dragging the stones inwards by the aid of their mouths, no doubt by suction. 'After two nights some of the holes had eight or nine small stones over them; after four nights one had about thirty, and another thirty-four stones.' One stone which had been dragged over the gravel-walk to the mouth of a burrow weighed two ounces; and this proves how strong worms are."

The object of this plugging Mr. Darwin surmises to be that of "checking the free ingress of the lowest stratum of air when chilled by radiation at night."

Now, concerning the apparent intelligence displayed in these plugging operations, Mr. Darwin "observed carefully how worms dragged leaves into their burrows; whether by their tips or bases or middle parts. It seemed more especially desirable to do this in the case of plants not natives to our country; for although the habit of dragging leaves into their burrows is undoubtedly instinctive with worms, yet instinct could not tell them how to act in the case of leaves about which their progenitors knew nothing. If, moreover, worms acted solely through instinct or an unvarying inherited impulse, they would draw all kinds of leaves into their burrows in the same manner. If they have no such definite instinct, we might expect that chance would determine whether the tip, base, or middle was seized. If both these alternatives are excluded, intelligence alone is left; unless the worm in each case first tries many different methods, and follows that alone which proves possible or the most easy; but to act in this manner and to try different methods makes a near approach to intelligence."

A large number of experiments were therefore tried with leaves of various shapes, and both of endemic and exotic species. The results showed unequivocally that the part of the leaf which the worm seized for the purpose of dragging the whole into the burrow was not a matter of chance, but in an overwhelming majority of cases that part of a leaf was seized by the dragging of which the leaf would offer least resistance to being drawn into the burrow. Thus, for instance, "the basal margin of the blade in many kinds of leaves forms a large angle with the foot-stalk; and if such a leaf were drawn in by the foot-stalk, the basal margin would come abruptly into contact with the ground on each side of the burrow, and would render the drawing in of the leaf very difficult Nevertheless worms break through their habit of avoiding the foot-stalk, if this part offers them the most convenient means for drawing leaves into their burrows."

Again, in the case of pine-leaves consisting of two needles joined to a common base, it is almost invariably by this base that the worm draws in the pair of leaves, and it is evident that, as the worm cannot lay hold of the two diverging points at the same time, this is the only part of the leaf by seizing which they would be able to drag the whole into their burrows. Mr. Darwin tried in some leaves tying or cementing the two diverging points together; but the worms still preferred the bases. Still further to test the hypothesis of chance, elongated triangles were cut out of paper and given to the worms instead of leaves. Here "it might certainly have been expected, supposing that worms seized hold of the triangles by chance, that a considerably larger proportion would have been dragged in by the basal than by the apical part"; while, inasmuch as the latter was in a literal sense the thin end of the wedge, it was the part which intelligent action would be most likely to choose. The results of many experiments with these paper triangles showed that "nearly three times as many were drawn in by the apex as by the base. . . . We may therefore conclude that the manner in which the triangles are drawn into the burrows is not a matter of chance, ...

and we may infer—improbable as is the inference—that worms are able by some means to judge which is the best end by which to draw triangles of paper into their burrows."

On the question of defining such action as intelligent or non-intelligent, Mr. Darwin refers to the criterion "that we can safely infer intelligence only when we see an individual profiting by its own individual experience"; and he adds that "if worms are able to judge, either before or after having drawn an object close to the mouths of their burrows, how best to drag it in, they must acquire some notion of its general shape," and thus guide their actions by the result of individual experience.

Assuredly these observations are most interesting, and it would seem well worth while to try whether, by a series of lessons with similar triangles of paper, an individual worm could be taught to lay hold of the apex in a greater and greater proportional number of cases; if so, there could no longer be any question as to the intelligent nature of the action.

The only other observations with which we are acquainted pointing to the existence of intelligence in annelids are those of Sir E. Tennant ("Natural History of Ceylon," p. 481).

The remaining chapters of the book are occupied with the subject of its title, and in their course many quantitative results are given of the amount of mould which worms are able to cast up. Thus, for instance, a certain field was thickly covered with marl. Twenty-eight years afterwards this layer of marl was found buried by mould to a depth varying between twelve and fourteen inches. Several other similar cases are given, the most interesting being that of a field which adjoins Mr. Darwin's own house. This was last ploughed in 1841, then harrowed, and left to become pasture land. Then

"For several years it was clothed with an extremely scant vegetation, and was so thickly covered with small and large flints (some of them half as large as a child's head) that the field was always called by my sons 'the stony field.' When they ran down the slope the stones clattered together. I remember doubting whether I should live to see these larger flints covered with vegetable mould and turf. But the smaller stones disappeared before many years had elapsed, as did every one of the larger ones after a time; so that after thirty years (1871) a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with his shoes. To any one who remembered the appearance of the field in 1842, the transformation was wonderful. This was certainly the work of the worms, for though castings were not frequent for several years, yet some were thrown up month after month, and these gradually increased in numbers as the pasture improved. In the year 1871 a trench was dug on the above slope, and the blades of grass were cut off close to the roots, so that the thickness of the turf and of the vegetable mould could be measured accurately. . . . The average accumulation of the mould during the whole thirty years was only ·083 inch per year; but the rate must have been much slower at first, and afterwards considerably quicker."

Numberless other corroborative cases are given, but we have no further space to enter into their details. Large stones are slowly undermined and sunk by worms, and woodcuts are given to illustrate actual measurements made by Mr. Darwin or his sons of the rate of sinking in particular cases. These measurements show that in the course of two or three centuries large blocks of stone (*e.g.* 67 × 39 × 15 inches) may become completely buried. Thus we are not surprised to learn that old pavements and low walls are subject to the same process, and many instances are given which have been observed by Mr. Darwin or his sons of the remains of Roman houses buried so far beneath the soil that the latter has been ploughed for years without any one having suspected the presence of walls and pavements beneath. In some cases the thickness of the mould or soil above such remains was found to be twenty, thirty, and even forty inches.

The actual weight of worm-castings thrown up in one year was calculated in one case to amount to 18·12 tons per acre.

Such being the work that worms are able by their gradual and cumulative action to accomplish, it becomes evident, as pointed out in Mr. Darwin's paper more than forty years ago, that worms must play an important part in the process of denudation. This topic is therefore treated at length, and it is shown that over and above the mechanical action already described, worms materially assist the process of denudation by the chemical actions incidental to digestion. For

"The combination of any acid with a base is much facilitated by agitation, as fresh surfaces are thus continually brought into contact. This will be thoroughly effected with the particles of stone and earth in the intestines of worms, during the digestive process; and it should be remembered that the entire mass of the mould over every field, passes, in the course of a few years, through their alimentary canals. Moreover as the old burrows slowly collapse, and as fresh castings are continually brought to the surface, the whole superficial layer of mould slowly revolves or circulates; and the friction of the particles one with another will rub off the finest films of disintegrated matter as soon as they are formed. Through these several means minute fragments of rocks of many kinds and mere particles in the soil will be continually exposed to chemical decomposition; and thus the amount of soil will tend to increase."

And,

"The several humus-acids, which appear, as we have just seen, to be generated within the bodies of worms during the digestive process, and their acid salts, play a highly important part, according to the recent observations of Mr. Julien, in the disintegration of various kinds of rocks."

Further,

"The trituration of small particles of stone in the gizzards of worms is of more importance under a geological point of view than may at first appear to be the case; for Mr. Sorby has clearly shown that the ordinary means of disintegration, namely, running water and the waves of the sea, act with less and less power on fragments of rock the smaller they are."

This assistance which worms lend to the process of denudation is of special importance in the case of flat or gently-inclined surfaces, for here it is not improbably the chief agent at work. Castings thrown up during or shortly before rain flow for a short distance down an inclined surface, and the finest earth is washed completely away. Again, during dry weather, the disintegrated castings roll as little pellets, and a strong wind blows all the castings, even on a level field, to leeward.

One other observation must be quoted, which, besides being of interest in itself, also has reference to the important subject of denudation :—

"Little horizontal ledges, one above another, have been observed on steep grassy slopes in many parts of the world. Their formation has been attributed to animals travelling repeatedly along the slope in the same horizontal lines while grazing, and that they do thus move and use the ledges is certain; but Prof. Henslow (a most careful observer) told Sir J. D. Hooker that he was convinced that this was not the sole cause of their formation."

It is then shown that the initial cause of these ledges is the burrowing of earthworms. For,

"If the little embankments above the Corniche Road, which Dr. King saw in the act of formation by the accumulation of disintegrated and rolled worm-castings, were to become confluent along horizontal lines, ledges would be formed. Each embankment would tend to extend laterally by the lateral extension of the arrested castings; and animals grazing on a steep slope would almost certainly make use of every prominence at nearly the same level, and would indent the turf between them; and such intermediate indentations would again arrest the castings."

Thus, on the whole, it will be seen how important an agency in nature Mr. Darwin has shown the action of worms to be, so that, in his own concluding words, "it may be doubted whether there are many other animals which have played so important part in the history of the world as have these lowly organised creatures."

George J. Romanes

OUR BOOK SHELF

The Atlas-Geography. By A. H. Macdonell. (London: H. K. Lewis, 1881.)

Under this title Mrs. Macdonell has attempted to supply what she believes to be a want long felt in teaching geography to young children. She finds, as every teacher finds, that children prefer the map to the book, and so she provides the means of teaching geography by means of an atlas. The Atlas-Geography consists of nine double maps. First we have in each case a coloured map with the leading names filled in, and facing it a list of the leading features in the map, countries, their divisions, towns, oceans, islands, capes, rivers, &c., which the children learn by heart, fixing at the same time their positions on the maps. Following this is a corresponding uncoloured map, without names, on which the children should be able to point out the features without assistance. Facing this is an interesting and simple descriptive account of the leading characteristics of the continent or country to which the map refers. It will thus be seen that in the hands of a painstaking and judicious parent or teacher the Atlas-Geography ought to prove a most valuable help in interesting children in the subject, and in enabling them to acquire the leading facts. The maps are well executed, clear, and not over-crowded; they are the World, Europe, Asia, Africa, Australia, North America, South America, the British Isles, and Palestine.

Gesammelte Abhandlungen und kleinere Schriften zur Pflanzengeographie. The collected treatises and shorter writings on Phytogeography of the late A. Grisebach, edited by his son, Dr. Ed. Grisebach. 8vo, pp. 628. (Leipzig: Wilhelm Engelmann.)

As the editor states in his preface, the present volume combines for the first time the numerous writings on phytogeography of the late Prof. A. Grisebach, spread over a period of thirty years, and scattered in various journals and publications, several of them very difficult of access. Constant reference is made to many of these writings in the "Vegetation der Erde" (1872); hence their publication in a collected form is a great boon. In addition to those article published previous to the "Vegetation der Erde," this volume contains the author's subsequent reports (1866-76) on the progress in the geography of plants. It also contains a biographical sketch of the late Prof. Grisebach, together with the bibliography of his works. An excellent French translation of the "Vegetation der Erde" appeared in 1874, but no English edition has been published, nor would we recommend the publication of one now, because the data that have been accumulating during the last decade would justify the publication of an original work, treating the subject from a different standpoint.

W. B. H.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

The Solar Outburst of July 25, 1881

In the interesting account of a solar outburst on July 25 contained in your last number (p. 508), Mr. Hennessey says that "unhappily the sun remained invisible till July 30." Referring to our sketches of the solar surface, I find that the nearest in time to the date of the outburst are those made on July 21 and 27. On the intervening days clouds prevented all solar work. The sketch on July 21 shows the groups in the [*n p*] quarter of Mr. Hennessey's disk, and that of July 27 gives those in the [*n f*] and [*s f*] portions, and also the two groups in the [*n p*] which were farthest from the centre on the 21st. There was certainly not the slightest trace on the 21st of the remarkable group which burst forth so suddenly on the 25th, and there can be very little doubt that the spots in the [*n p*] quarter on the 27th are identically the same as those in the [*n f*] quarter on the 21st. Drawings of the solar disk are made here on every available day, and the position of each spot is marked with the greatest exactness; but when the sky is cloudy, as on the 27th, it is not always possible to fill in all the details. The exact position of each spot is invariably marked before any details are sketched, and therefore, as the definition on the 27th was good, the group, which suddenly appeared near the centre of the disk on the 25th, must already have completely vanished. I might mention, in conclusion, that our magnetic photograms show no sign of any disturbance synchronous with the solar outburst.

S. J. Perry

Stonyhurst Observatory, Whalley, September 30

On the Velocity of Light

With reference to Lord Rayleigh's article on the Velocity of Light (vol. xxiv. p. 382) I, and possibly others, find it difficult to follow him when he says, in the case of all the methods for determination of the velocity of light except the aberration method, that the velocity arrived at is the "group velocity," and not necessarily the "wave velocity." I, for one, should be glad of further exposition. Does not Foucault's revolving mirror experiment, for instance, measure the velocity of motion of the centre of the disturbance which is transmitted from mirror to mirror? And would it not be the case that, if the waves moved faster than the groups, new groups would be continually formed ahead, the old ones dropping out behind: so that the centre of the disturbance would not remain in any given group? Further, is any credence to be given to the result that blue light travels anything like 1·8 faster than red light, while this is unconfirmed by the colours of Jupiter's satellites?

W. H. Macaulay

Mountsorrel, August 29

An Aquatic Hymenopterous Insect

The following circumstance may prove interesting, and probably new, to some of your entomological readers. On September 10, in a gathering of pond-water made in this neighbourhood and brought home for microscopical examination, a somewhat singular and unusual object presented itself, but speedily making its way to the sediment at the bottom, it became lost to sight. Upon the evening of the 12th, or after the lapse of fully two days, while holding the bottle to the light, the same object again appeared, swimming or flying in mid-water with a peculiar jerky movement resembling that of some of the Entomostraca, and for one of which I at first mistook it. On removal by means of a dipping-tube to a zoophyte trough for fuller examination, it proved, to my great surprise, to be one of the small Hymenopterous flies of the Proctotrupid family, and here it continued its active movements, now walking and running upon the bottom and sides of the trough, now flying, as it were, through mid-water by the energetic movements of its wings, but apparently making no effort to escape. Examination thus proving no easy task while living, and fearing the loss of a specimen of habits so unique, I decided upon securing it permanently as a microscopic mount. With a minute description I need not now trouble you, but as neither in Westwood nor in any other of the authorities on such subjects at my command I can find any record of this singular fact having been hitherto observed, either in connection with the parasitic Hymenoptera or any other similar insects in the perfect state adapted apparently to an aërial life alone—that they should quit their natural habitat for so lengthened a sojourn in the water—I would make the inquiry as to whether any like occurrence has been noted by any of your other correspondents. EDWIN BOSTOCK

Stone, October 6

[Our correspondent has had the good fortune to re-discover in this country the little Hymenopterous insect found almost simultaneously by Sir John Lubbock and Mr. Duchess in 1862, to which the former applied the name *Polynema natans* (*Transactions* of Linnean Society, vol. xxiv. part ii. p. 138, 1863). The insect is parasitic in its larval stage *in the eggs of dragon-flies*. A brief summary of its peculiarities is given in Lubbock's "Origin and Metamorphoses of Insects" (Macmillan and Co., 1874). More recently Prof. Westwood has suggested (*Transactions* of Linnean Society, second series, "Zoology," vol. i. part viii. p. 584, 1879) that the insect is scarcely a true *Polynema*, but rather an *Anaphes*, or the type of a new genus. A true Ichneumon (*Agriotypus armatus*) has long been known to be parasitic in caddis-worms, and therefore also aquatic in its habits.—ED.]

Practical Physics for Boys

IN Prof. Parker's very valuable and interesting paper (vol. xxiv. p. 543) he says: "The consequences of setting large classes of young boys to make oxygen, or to take a specific gravity . . . each for himself, might prove rather subversive of order than conducive to improvement." It may be interesting to some of your readers to know that at Clifton College we have lately tried the experiment of turning some of our ordinary physics classes, numbering from twenty-four to thirty boys, bodily into the physical laboratory, where they work at weighing, measuring, finding specific gravities and such matters, under the control of a single master. The boys work in pairs, each with a little manual of instruction, and each pair with a separate cupboard of cheap apparatus. Two such classes are taken by Mr. Worthington and myself, and we are both agreed that whatever difficulties we may feel, we have none in the matter of discipline. On the contrary, the boys are with scarcely an exception most keen and eager at this work. I understand that similar classes in practical chemistry will shortly be set on foot by Mr. Shenstone in our chemical laboratory. H. B. JUPP

Clifton College

A New Comet

I OBSERVED a telescopic comet in Leo on the mornings of October 4, 5, 6, and 10. The rough positions, as I estimated them, were R.A. 9h. 22m., Dec. 16° N. on the 4th, and R.A. 9h. 36m., Dec. 15° N. on the 10th. The motion is about 30' daily eastwards. When the present bright moonlight is gone the comet will be a fairly bright object in the telescope. At the end of the present week it must be looked for immediately preceding η Leonis.

When I saw it first, on the morning of October 4, it looked like a bright nebula, and I cannot understand how I missed it on the mornings of September 29 and October 1, when I had carefully swept the same region for several hours before sunrise. The inference is that it is getting brighter. W. F. DENNING

Ashley-Down, Bristol, October 10

A Kinematical Theorem

SOME little time ago Mr. Kempe published in NATURE a theorem of interest in kinematics. I subsequently stated in the same pages that this theorem and all theorems of uniplanar kinematics are most simply and properly proved from the consideration that epicycloidal motion is the basis of all uniplanar motion—and that this is also the proper principle on which to base the theory of planimeters. It may not be out of place to occupy a few lines in NATURE with another curious kinematical theorem allied to Kempe's, which I have just found by this method. *If a plane*, A, *move about in any manner over a fixed plane*, B, *and return to its original position after any number of revolutions, all those right lines in the plane* A *which have enveloped glisettes of the same area, are tangents to a conic, and by varying the area of the glisette we obtain a series of confocal conics.* I use the term *glisette* under protest—"line roulette" would be better, as the former name is more applicable to a curve of another sort. GEORGE M. MINCHIN

Royal Indian Engineering College

Integrating Anemometer

MY attention was called to a letter on this subject in your issue of the 29th ult. (vol. xxiv. p. 510), though not in time to enable me to answer it last week. I take this opportunity of stating that the gentleman to whom the idea of the instrument was originally due, and who has defrayed the whole cost of its construction, is the Rev. J. M. Wilson, M.A., head-master of Clifton College (not Dr. Wilson, as mis-stated in the Association *Journal* at York and in your abstract). The objection that the air does not move "parallel to itself," by which I presume is meant in planes parallel to its general direction, does not apply to this any more than to any other cup anemometer. Only the horizontal component of the wind's velocity is sought, and this is given with tolerable accuracy. I have no means of knowing to what extent Mr. Burton's integrator resembles the anemometer in question, but it should be noticed that the two instruments are of a different kind and for a different purpose. Mr. R. Scott was in the chair when the paper was read at York, and joined in the discussion. Prof. Stokes was also present, and has since been in correspondence with me on the matter. Neither of these gentlemen, however, mentioned any other instrument as at all resembling it; indeed upon its being compared to that of Dr. von Oetlinger, Mr. Scott took occasion to point out at least one important difference, viz. the cost. H. S. HELE SHAW

University College, Bristol, October 10

Infusorial Parasites on Stickleback

MR. N. H. POOLE (NATURE, vol. xxiv. p. 485) is apparently right in anticipating that he has discovered either a new habitat for *Trichodina pediculis* or a new representative of that infusorial genus. Although hitherto regarded as a parasite only of the fresh-water polypes, *Hydra vulgaris* and *H. viridis*, I have recently obtained specimens of the type in question living as a parasite, or rather a commensal, on the branchial appendages of the larva of the common newt, *Triton cristatus*. An allied, but marine species, *Trichodina scorpæna*, has been recently described by Prof. Ch. Robin, that infests in a similar manner the branchia of fishes belonging to the genera *Trigla* and *Scorpæna*, and a further search will no doubt reveal a yet more extensive distribution of the Urceolaridæ, including *Trichodina*, among the Piscine race. Mr. Poole will find full particulars of the data here referred to, together with an account and illustrations of all the forms so far relegated to this somewhat remarkable infusorial group, in Part V., p. 645 *et seq.*, of my "Manual of the Infusoria," just published. W. SAVILLE KENT

The Dark Day in New England

REFERRING to your paragraph in last week's NATURE (p. 540) about the remarkable phenomenon which occurred in New England on September 6, I find in the recently-published "History of Lynn, Massachusetts," the following:—

"1716.—Extraordinary darkness at noonday October 21st; dinner tables lighted."

"1780.—Memorable dark day May 19th; houses lighted as at night." CHARLES W. HARDING

Lynn, October 7

THE EVOLUTION OF THE CRYPTOGAMS[1]

II.

THE direction and many of the gradations through which the highest classes of the vegetable kingdom have been developed from the lower are preserved in the palæontological record. In order to decipher them, however, certain facts must be kept in view: chiefly, that the higher and more complex organisations, are the most susceptible to changes in the external conditions upon which they are dependent, and therefore more readily destroyed, while the simpler the organisation the more yielding or plastic it is, and the greater the chance that it will be able to survive by adapting itself to change. Thus the superb Cryptogams of the Carboniferous succumbed no doubt to great physical changes, but the more humble of them bent to the new conditions, and even found therein an impetus leading to unexpected developments, which eventually carried them far beyond their more advanced brethren.

Tracing back the origin of vegetable life, we see that it consisted nearest its source solely of Algæ. A little later, Cryptogams appeared, and developed their maximum during the Palæozoic period. Next, almost synchronously, Gymnosperms are met with, and after a long time preponderate; and then Angiosperms, obscure and subordinate at first, begin, towards the close of the Secondary period, to take the first rank.

Most of the lowest Algæ, such as Ulva and Conferva, are scarcely of a texture to have left traces of their existence, but eight still existing Diatoms have been discovered in British Coal.

The next group, morphologically, of Algæ—the Siphoneæ—have been shown by M. Munier-Chalmas to be abundant in the Trias and Secondary rocks, and to be analogous, or perhaps identical, with the existing Cymopolia and Acetabularia. It is unfortunate that, owing to the texture of most of the Algæ, observation has to be concentrated on the few groups that could be preserved. In the Silurian the remains of these are numerous, and of forms completely differing from existing types.

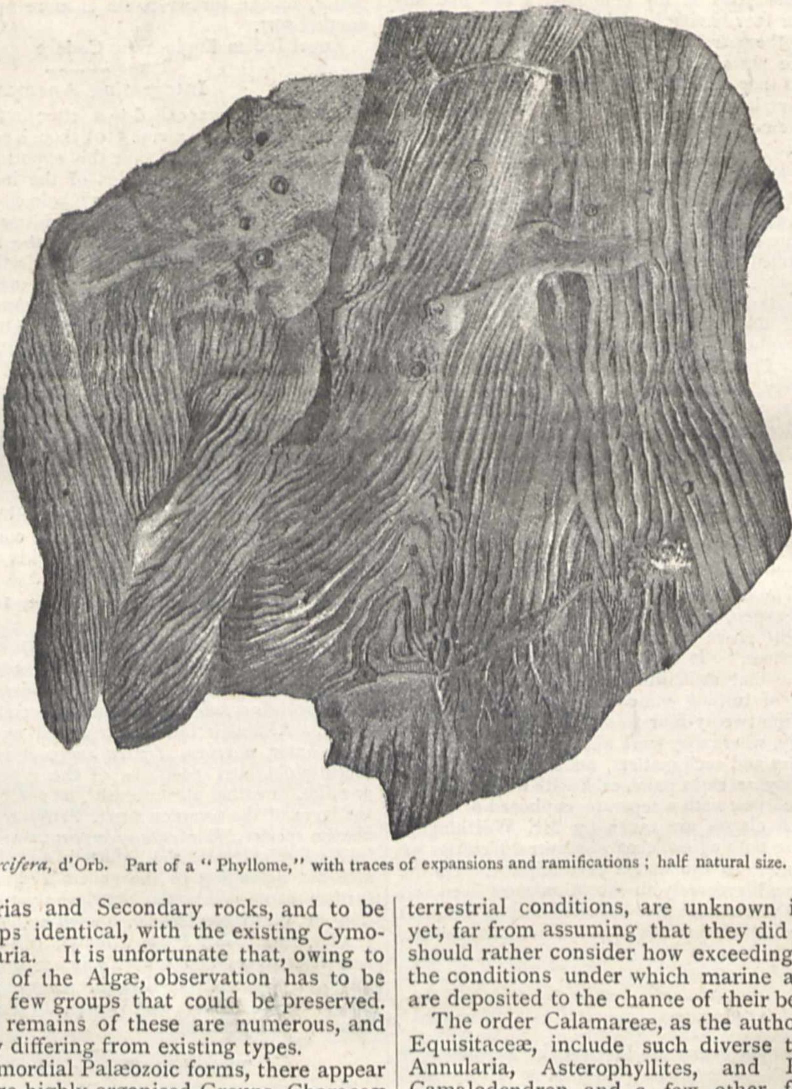

FIG. 1.—*Bilobites furcifera*, d'Orb. Part of a "Phyllome," with traces of expansions and ramifications; half natural size. Silurian of Bagnols.

Following the primordial Palæozoic forms, there appear successively the more highly organised Groups, Characeæ in the Trias, Laminariaceæ in the infra-Lias, and finally Fucaceæ in the Eocene.

The Mosses and Liverworts, which seem to indicate the stages through which Algæ gradually became adapted to terrestrial conditions, are unknown in the older rocks; yet, far from assuming that they did not then exist, we should rather consider how exceedingly unfavourable are the conditions under which marine and estuarine strata are deposited to the chance of their becoming imbedded.

The order Calamareæ, as the authors prefer to call the Equisitaceæ, include such diverse types as Calamites, Annularia, Asterophyllites, and Equisteum, though Camalodendron and a few other forms are excluded. The group is characterised by the arrangement of their organs in whorls, whether these are true leaves or the modified leaves which support the sporangia. The sporangial whorls either occur together and form a terminal fruit, or are placed alternately with whorls of true leaves, and the sporangial bracts are either disunited or coalesce to form a sheath. Modifications of one or

[1] "L'Évolution du Règne Végétatale." Les Cryptogames. Par MM. Saporta et Marion. Bibliothèque Scientifique Internationale, xxxi. (1881.) Continued from p. 75.

other of these characters are the foundations of all the Palæozoic genera yet known. In the extinct Carboniferous forms the fertile or sporangial whorls alternated with, and were protected by, the overlapping whorls of barren leaves, while in Equisetum the sporangial whorls are naked and clustered in a terminal spike, an arrangement considered by Saporta and Marion to be more favourable to the dispersion of the spores. Annularia and Asterophyllites were floating or procumbent plants. Calamites strongly resembled the existing aquatic Equisitaceæ, though exceeding them twenty times in size, and surpassing them in development by the possession of spores of two sexes. Their more complex structure and consequent inadaptability to changed conditions, favoured, the authors believe, their early extinction in the Permian. In the Trias, and until the Jurassic, several slightly modified genera coexisted with true Equisetum, and the survival of the latter, one of the genera that have persisted almost unchanged from the Carboniferous, is probably due to their simple organisation, easy dispersion of the spores, and the immense depths to which their rhizomes penetrate.

FIG. 2.—*Bilobites Vilanovæ*, Sap. and Mar. Base of a "Phyllome." Silurian of Andalusia.

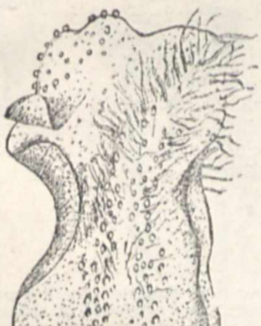

FIG. 3.—Prothallus of an Osmunda aged eight months, slightly magnified to show the double row of archegones down the centre.

The structure of ferns, unlike that of Equisitaceæ, lends itself to infinite diversity. The fronds may be simple or multipartite, without their form implying the slightest degree of relationship, and supposed alliances between fossil and recent ferns, such as Ettingshausen has based upon the aspect and venation of the frond, are declared by the authors to be valueless and misleading.

The earliest ferns had simple fronds, and probably resembled in their vegetative organs the Hymenophylleæ, a group already well represented in the Carboniferous. Next in order come the Osmundaceæ, if the relative complexity of their prothallus and simplicity of sporangia are accepted as indications of inferiority.

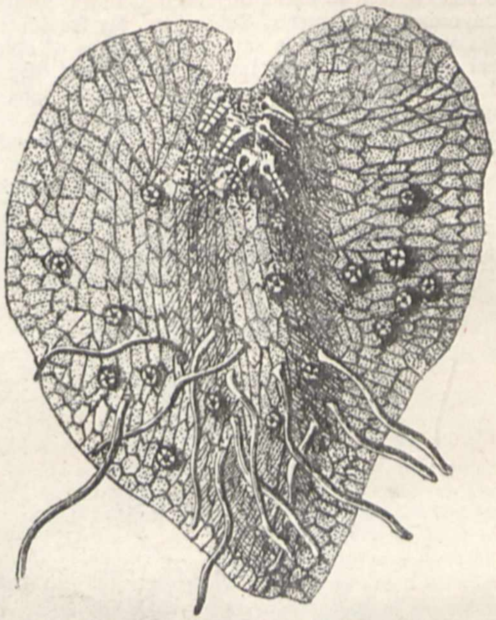

FIG. 4.—Under side of the prothallus of another fern, more magnified, showing the rhizoid radicles, the antherids dispersed over the surface, and the archegones clustered at the terminal notch.

The relative perfection of the sporangium when taken as the essentially important organ, leads to a classification coinciding approximately with the order in which the groups made their appearance:—Hymenophylleæ Osmundaceæ, Schizeaceæ, Gleicheniaceæ, Marattiaceæ, Cyatheæ, Polypodiaceæ.

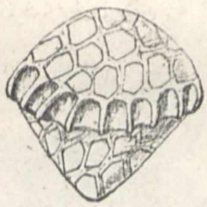

FIG. 5.—Sporangium of Hymenophyllum, girt transversely by the ring of cellules which disrupt the spore-case.

FIG. 6.—Sporangia of Osmundaceæ, showing dorsal dehiscence. 1 and 2, sporangia of *Todea Africana*—1, ventral surface; 2, dorsal surface; 3, sporangium of Osmunda seen dorsally, and showing the infra-apical group of cellules which disrupt the spore-case.

From the simplest type of sporangium, two lines of increasing differentiation in the organ, or its support, can be traced—one leading to the Polypodiaceæ through the Cyatheæ, the other to Schizeaceæ, Gleicheniaceæ, and Marattiaceæ.

The earliest fern of which the fructification is known is the Devonian Palæopteris, Schimper. Its fructification consists of aborted leaflets supporting groups of oblong, ringless sporangia opening into two valves and disposed in threes on pedicles. Rhacopteris, of the same age, and perhaps not generically differing, has fructification which unites in a higher degree the characteristics of Osmunda and Botrydium, and giving birth probably to the Botryopterideæ of the later Carboniferous flora. Another genus, Seftenbergia, is allied by the structure of its sporangium to Angiopteris (Marattiaceæ), though each sporangium is as yet isolated. The Palæozoic ferns did not at this period essentially differ from Osmunda and Todea.

The earliest example of definite grouping in the

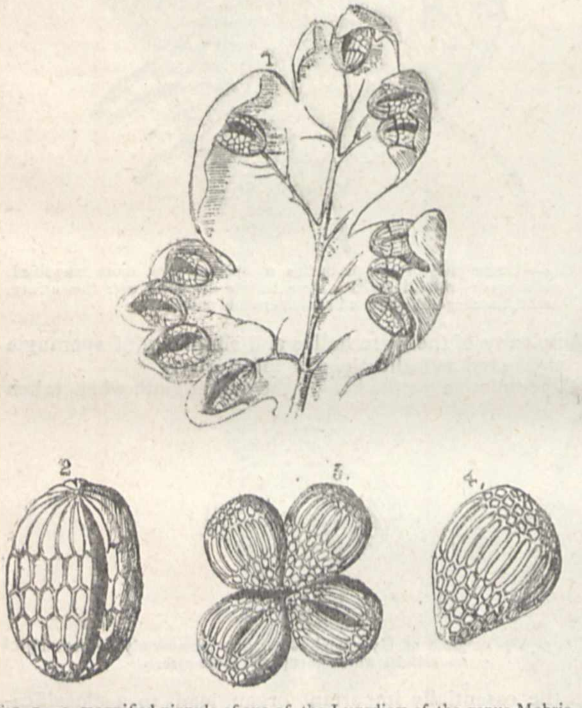

FIG. 7.—1, magnified pinnule of one of the Lygodieæ of the genus Mohria, showing the arrangement of the sporangia on the under side of the frond; 2, sporangium of the same, showing the group of apical cellules which disrupt the spore-case; 3, sorus of Gleichenia, showing the peripheral arrangement of the cellules which disrupt the spore case; 4, sporangium before dehiscence.

sporangia is furnished by Oliogocarpia, in which three to five sporangia are inserted on a point near the ultimate terminations of the venules; but even here, though contiguous, they are distinct, and can be separated. In the later Carboniferous, Marattioid ferns for the first time occur with the sporangia united in a composite organ called a synangium, and soon after the Marattiaceæ reached their maximum development, and commenced, through forms now extinct, to differentiate towards the Gleicheniaceæ. The stages of development of the latter, and of the Schizeaceæ, are more difficult to trace, though both are represented in the Palæozoics by Howlea and Seftenbergia respectively. The actual genus Gleichenia does not appear until the inferior Oolite, and Lygodium until the Cretaceous.

The Cyatheæ are represented in the Carboniferous by Thyrsopteris and in the Jurassic by Dicksonia, while true Polypodieæ cannot be traced farther back than the Rhætic. They seem to have developed suddenly, and among them are a number with their sporangia grouped in sori as in Gleichenia, yet possessing in other respects the structure characteristic of Polypodium.

The Ophioglossaceæ are related to the most ancient ferns by the arrangement and structure of their sporangia, and to Isoëtes and Lycopods by the form of their prothallus. They even present affinities with Sigillaria, and represent, the authors conjecture, an almost unchanged type, older than the differentiation of either ferns, Lycopods, or Rhizocarps.

The Lycopodiaceæ are divided into isosporous and

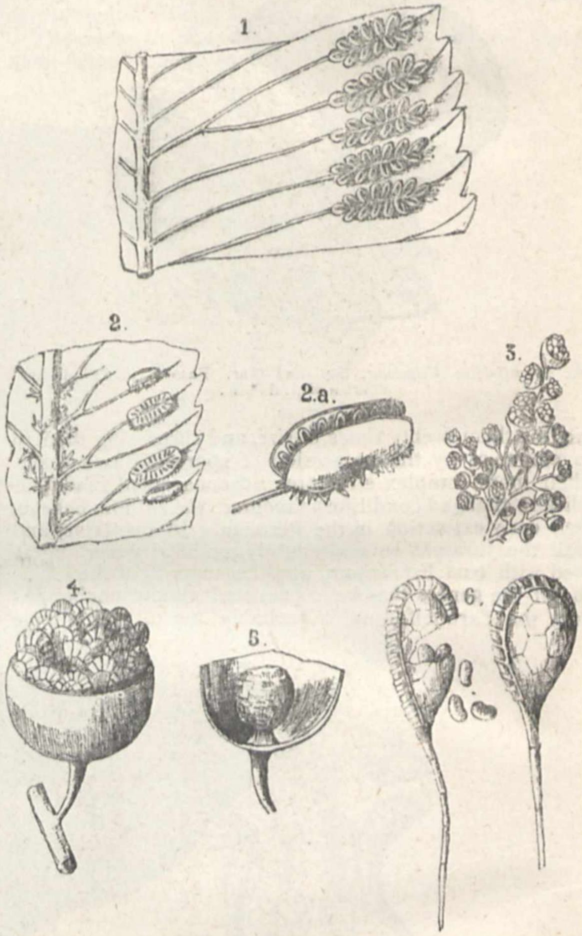

FIG 8.—1, part of pinnule of Angiopteris, with sporangia clustered in groups, but not united; 2, part of pinnule of Marattia with sporangia joined together in a synangium; 2*a*, a synangium magnified; 3, extremity of the fertile frond of one of the Cyatheæ, *Thyrsopteris elegans*; 4, a magnified receptacle of the same, in form of a pedunculated cup, full of sporangia which are girt with a jointed ring of cellules; 5, section through an empty cup, showing the support to which the sporangia are attached; 6, two highly-magnified sporangia of Polypodiaceæ, one dehiscent, girt vertically by a jointed ring and on pedicles.

heterosporous kinds. The former, comprising Lycopodium and a few tropical genera, have been found fossil in the Old Red of Thurso and the Carboniferous of Saarbruck and Autun, their small size and retiring habits having doubtless caused their relative rarity in stratified rocks. The heterosporous, or more perfected kinds, obtained a magnificent development in the Carboniferous, favoured by the warm and humid climate, free from seasonal changes, which then seems to have prevailed, and only declined when these conditions ceased. They are at present represented by Selaginella, a genus which has scarcely changed since the Carboniferous. The sporangia are globose, pedunculated, and situated towards the base of the bracts which compose the fruit-

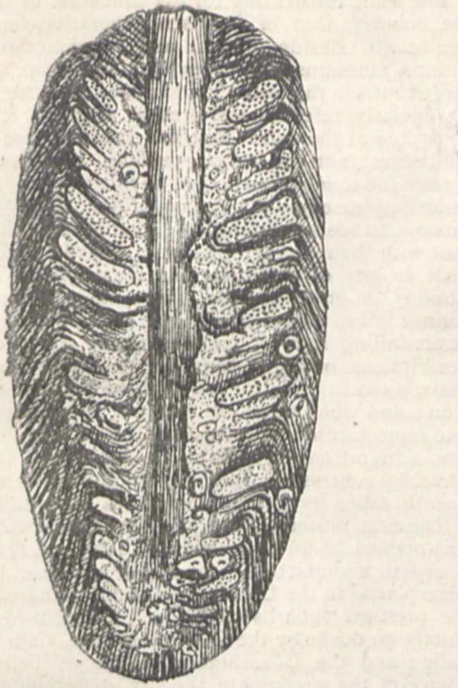

Fig. 9.—Lepidostrobus, the reproductive organ of Lepidodendron. Longitudinal section of sporangiocarp of *Lepidostrobus Dabadianus*, Schimp., showing the lower sporangia containing macrospores and the upper microspores; half natural size.

spikes, and either contain two to eight macrospores, or small and very numerous microspores. In the germination of these spores the approach towards Gymnosperms becomes exceedingly apparent, and is consequently dwelt on at some length, the researches of Sachs, Luersen, and others being largely referred to. An even higher stage was in all probability reached in the Lepidodendrons, the vigorous and splendid growth of which formed the culminating development of the Lycopodiaceæ. The mathematical regularity of their growth, even in the most minute internal structure, is very striking. They formed large trees with acicular or falcate, perhaps deciduous leaves, and bore cones in pairs at the extremities of certain branches, differing exteriorily but little from those of Gymnosperms. The expanded bases of the scales or bracts bore the sporangia, those containing the macrospores being nearest the base. The stem comprised several layers, the centre being of pith formed of elongated prismatic cells. The next layer was woody, and gave off simple vascular threads to each leaflet, these penetrating obliquely the succeeding region of parenchyma and the cortical layers. The bark increases in density towards the exterior, and in some species the interior pith is absorbed in the woody layer.

Lepidodendron, with the greater part of the Palæozoic flora, became extinct during the Permian, leaving as representative the humble Isoëtes. This, however, is not necessarily a degraded type, and may have existed since Palæozoic times, though only known fossil in the later Eocenes, where it in no way differs from existing forms.

The Rhizocarps are beyond doubt the highest existing form of Cryptogam, but though in many respects so nearly approaching to Phanerogams, they are not, as we see them now, in the absolutely direct line of evolution. In all, the sporangia are protected by an enveloping altered leaf, or segment of a leaf, forming a fruit called a sporocarp, which in most cases attains a high degree of complexity. The entire group is aquatic, and stands in the same position towards fossil Rhizocarps that Isoëtes does to the Lepidodendrons. The Carboniferous Sphenophyllum has been shown to correspond to Salvinia, and the Rhætic

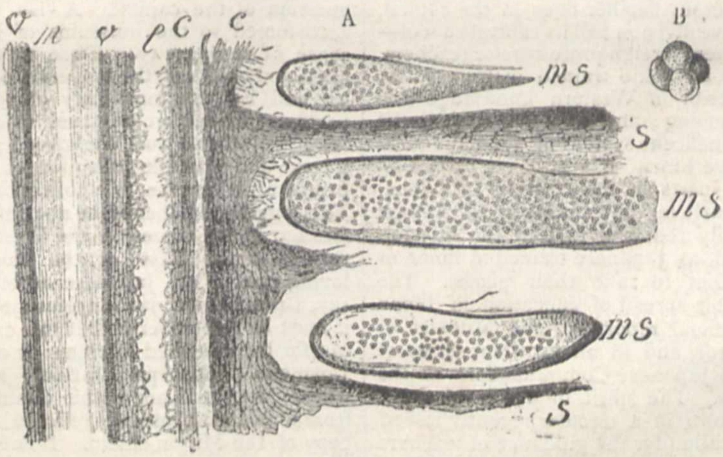

Fig. 10.—Reproductive organs of Lepidodendron with microsporangia and microspores. A, longitudinal section through upper part of sporangiocarp of Lepidostrobus (probably *L. Brownii*, Schimp.), from the neighbourhood of Pézenas (Hérault); M, the central medullary region formed of parenchyma with elongated prismatic cells; V V, the woody layer of fibro-vascular region next the pith, showing large scalariform vessels; L, lacuna, in which delicate and partly disintegrated cells are studded; C C, cortical layer composed of a very dense outer and an inner layer, separated by a loose, nearly destroyed parenchyma; S, "sporangiospores," supporting very elongated microsporangia filled, M S, with microspores aggregated in fours (these are slightly exaggerated in size); B, group of microspores magnified.

Sagenopteris to the Marsiliaceæ. Though the vegetative organs in the extinct forms attained far finer proportions and a higher and more delicate structure, the fructification, in Salvinia especially, appears the more complex. The existing genera have only been met with in the Eocene and Oligocene.

Thus while Angiosperms all present similarity in the reproductive process, Cryptogams preserve many of the stages by which the evolution of the higher forms has been accomplished. They also present every gradation in their vegetative organs, from the simplest and purely cellular plant to the equals of Phanerogams in point of structure. Except the Protophytes, all Cryptogams are impregnated by antherids, and present the antagonistic and alternate asexual and sexual generations, these being in fact their distinguishing characters. The authors' task

—to trace step by step the progressive stages by which the prothalloid phase has been diminished, and the ever, though gradually, increasing approach in the complexity and mode of reproduction to the Phanerogams—has demanded the most patient and prolonged research. The promised second volume will further diminish the hiatus still left between Phanerogams and Cryptogams, and make clear, the authors believe, the precise lines through which the evolution of the one from the other has been accomplished.

J. STARKIE GARDNER

MUSEUMS AND EXHIBITIONS IN JAPAN

THERE is probably no function of Government which the rulers of new Japan have performed so adequately and thoroughly, with such persistence and such unvarying success, as that which consists in the education of the people. It would be impossible in the space at our disposal to describe the course and results of education under the usurpation of the Shôgun; suffice it to say that, though learning of a peculiar kind always received sup port and encouragement, these were given on no sound or general system. The masses were neglected as beneath consideration, while literary labour of the best kind was always rewarded. No Japanese Horace need ever have lacked a generous Mecænas. But it was not until the restoration of the Mikado and the overthrow of the feudal organisation that a system of universal education which should reach the lowest classes of the people was introduced, and the Government of Japan then looked abroad to those Western lands, to which the eyes of all Japanese were then turned, for models on which to base their new scheme. American teachers of eminence were first brought to the new University established in Tokio; these were soon followed by subordinate instructors for the various schools in the local centres, and in six years after the restoration there were two large educational establishments—the University and the College of Engineering—besides numerous smaller ones in the capital, while every administrative division had its central school—all provided with competent foreign professors or teachers. A large normal college in Tokio trained instructors for the schools in the interior in Western knowledge and Western methods of teaching; and from that time to the present the wise and beneficent system of general education adopted by the Government has gone on extending itself into the remotest parts of the country. As mentioned in a previous article, the number of foreign instructors was gradually reduced, first in the interior, afterwards at the capital, as Japanese trained at home or abroad became competent to take their places. The history of this remarkable spread of education in Japan will be found in the annual reports of the Minister of Education to the Emperor, and in an excellent series of papers published by the Japanese Commissioners to the Philadelphia Exhibition. The spirit in which this work is carried out is well shown in a circular recently issued by the Minister of Education for the guidance of teachers in elementary schools. According to the *Japan Mail* this document contains sixteen clauses, embodying a number of directions for the conduct of school officials. The chief points are (1) "the importance of imparting a sound moral education to the students, both by precept and example, since the condition of a man's heart is of far greater moment than the extent of his knowledge; (2) the necessity of proper hygienic arrangements, which have more effect upon the health of the students than gymnastics or any other physical training; and (3) the value of mental energy in a teacher, for without it he cannot possibly support the fatigue and trouble of really careful tuition." The circular goes on to advise teachers not to constitute themselves advocates of any particular religious or political doctrines, and to take every opportunity of increasing their own stock of knowledge.[1]

But while thus caring for the education of the youth of the country, that of its risen generation has not been neglected. Besides annual and triennial domestic exhibitions, museums have been established in most of the large towns in the country, and it is to these we would more particularly refer in the present article. It should be remarked at the outset that the Japanese are a nation of sightseers; not the vulgar, pushing, noisy mob to which we are too much accustomed in this country, but a quiet, orderly, pleased, and pleasing crowd. They are always anxious to see something new; failing this, they are content with their own temples and ancient festivals. In a visit to any of the numerous museums of Tokio on a Sunday or other holiday, the stranger from the West cannot fail to be struck with the order, good humour, and never-failing interest manifested by the people. The descriptions of the objects are generally very full and clear, so as to bring them within the meanest comprehension; and when these are read out to a group by some one more learned than the rest, the exclamations of wonder, admiration, or delight are incessant, and form a pleasing contrast to languid or imperfect interest frequently taken by our own crowds in their museums.

The first museum in Japan—the *Hakubutsu-kuwan*—was opened, as an experiment, in 1873. A few objects of Western manufacture and some Japanese productions were placed in the Confucian Temple, situated in one of the prettiest suburbs of Tokio. Vast crowds, attracted chiefly no doubt by the foreign exhibits, visited the place daily; and the Government, acting, we believe, on the advice of the governor of the city, determined to enlarge the exhibition considerably and make it permanent. It was accordingly removed to a more central position, the partially-dismantled residence of one of the old nobles being chosen for this purpose. Here the collection was deposited and gradually increased, until at the present time it fills a range of narrow buildings nearly a quarter of a mile in length. This may be called the permanent museum of the capital. A visit to it would strike one accustomed to the museums of Europe with a certain sense of incongruity. Close to the lacquered bullock-carts and chairs of the emperors of a thousand years ago we find English machinery of yesterday: in one compartment we see art treasures of a remote antiquity; in the next, Minton and Wedgwood; a corridor containing a large and valuable collection of the old paper currency brings us, it may be, to a collection of modern glassware. This jogging together of the ancient and modern, of articles familiar in the homes in the West with the priceless art rarities of the East; of the products of the skill and loving care of old Japanese artists with, we may almost say, Brummagem, jars unpleasantly on foreign taste. But it must be remembered that this establishment is founded, not for the educated foreigner or even native, but for the Japanese shopkeeper, farmer, artisan, and labourer, whose interest is not a whit diminished when he passes from a beautful antique relic to a Bradford loom or a copy of the Milton shield. Indeed, we are not sure that

[1] As an instance of the general spread of elementary education, the present writer may take this opportunity of mentioning what he saw during an examination of some of the principal Japanese prisons in the summer and autumn of last year He found all the children and youths in gaol—in some cases numbering a few hundreds—attending the prison schools for four or six hours each day, while the adults attended in the evenings and on Sundays. He saw in the chief penal settlement in Tokio about three hundred boys learning reading, writing, and the simple rules of arithmetic. In the senior class the boys were learning ciphering *with European figures* from one of their own number. In the large prisons a teacher or teachers form portion of the staff; they are assisted by convicts who act as ushers or monitors. In the smaller ones an inmate—generally a political prisoner—is selected as master, and enjoys in return certain small advantages. The prison system of Japan, theoretical and practical, would well repay examination at the hands of a competent authority on penal discipline. The present Governor of Hongkong, Sir John Pope Hennessy, who has had much experience in the subject in his various governments, has expressed his high appreciation of the excellent condition of Japanese prisons.

the modern exhibits, trumpery as many of them would undoubtedly appear to us, do not attract more attention than the productions of ancient Japanese art industry. We have even heard it suggested that, by placing these various articles under one roof, the Government desired to check in their people an unreasoning admiration of everything foreign, by showing them what Japanese themselves have done in the olden time.

It would be impossible here to describe in detail even the most striking museums of the capital. The Government of the great northern island, Yeso, have established one containing specimens of the flora, fauna, and other productions of that territory near the sacred grounds of Shiba. In the great park at Uyeno, a northern suburb of the city, the Education Department exhibits all the educational appliances of most of the civilised countries of the globe; while in the same neighbourhood is a smaller museum containing a collection of ancient art treasures, to which the Emperor himself has contributed. In all the chief towns throughout the country also—notably in Osaka, Kioto, and Nagoya—museums have been established by the local authorities. Sometimes these contain only specimens of the productions, natural and artificial, of the province in which they are situated; but generally objects of more universal interest are to be seen. These, as we have before remarked, are thronged on holidays by crowds of eager sightseers, and it would be difficult, more especially for a foreign observer, to estimate accurately their beneficial effect on the nation at large, in humanising the people and stimulating healthy competition and production.

The temporary exhibitions have been not less successes than the permanent museums. An annual exhibition of domestic products is held at Kioto, in the old palace grounds, and lasts for 100 days; and a triennial one on a large scale takes place in Tokio. This also is reserved for domestic productions. The second of these has just been closed, an Imperial prince representing the Emperor at the closing ceremonial. His Majesty, having attended at the inauguration and at the distribution of prizes, was able to say (we quote from the report of the *Japan Gazette* newspaper) that there were over 800,000 visitors in 122 days. Each of the speakers on this occasion bore witness to the value of these exhibitions, and noticed the marked improvement in the exhibits now over those of three years ago.

The prospectus of a domestic exhibition of trees and shrubs has just been issued. It is to take place in February next year, and besides specimens of the forests and plantations under Government, private individuals are invited to send exhibits of timber. The exhibition will be under the control of the Department of Commerce and Agriculture, and the result will doubtless be an interchange of knowledge which will be of the utmost value in a country where wood is one of the most universal necessaries of life.

Two years since a most interesting exhibition took place at Nara, the site of an ancient capital of Japan. It was confined wholly to Japanese antiquities, and was under the direct patronage of the Emperor, who contributed many of the most valuable articles. We have referred in a previous paper to the success of an exhibition of the various instruments which have from time to time been employed to test the direction and intensity of earthquake shocks, which was held under the auspices of the Seismological Society of Tokio.

As cognate to the subject of this article we may refer to the public libraries of Japan. Lending libraries have existed in the country from very early times; but it is only recently that the Government have provided large collections of native and foreign works for students. One free library in Tokio, which was founded in 1873, contained a year ago 63,840 volumes of Chinese and Japanese works, 5162 English books, 6547 Dutch, and about 2000 volumes in other European languages. It possesses a large reading-room, provided with many leading foreign journals; admission is wholly free, and permission to borrow books for a certain period is easily obtained. The number of readers is about three thousand a month. Another, containing about 143,000 volumes, including many ancient books and manuscripts, is practically free, an entrance fee of less than a halfpenny being charged. In addition to these many of the leading towns throughout the country are provided with free libraries, which are much used and appreciated by students. The cost of foreign books renders these institutions peculiarly valuable to natives, who, as a rule, cannot afford to pay our heavy prices.

It will thus be seen that the introduction of museums and similar establishments was a happy move on the part of the Japanese Government; they are heartily appreciated by the people, and their educating influence is immense. With the exception of the newspaper press no Western institution has been so rapidly or so successfully acclimatised in Japan.

THE INTERNATIONAL EXHIBITION AND CONGRESS OF ELECTRICITY AT PARIS[1]

III.

THE Congress held its concluding sitting on Wednesday, the 5th inst., and was formally dissolved. Three international Commissions are to be appointed in accordance with the recommendations of the Congress, viz.:—

1. A Commission to determine what length of mercury at zero Centigrade, with a section of a square millimetre, has a resistance equal to the theoretical Ohm, that is, to 10^9 C.G.S. units.

2. A Commission for the following distinct purposes:—To arrange for a general system of observations of atmospheric electricity; to arrange for a general system of observations on earth-currents; to determine the best system of lightning-conductors; to investigate the practicability of a general system of automatic transmission by telegraphic wires of the indications of meteorological instruments. The idea of this last investigation is taken from the apparatus of M. van Rysselbergh, which we described in a previous notice. In fact it is understood that the Committee will report on the advisability of extending to Europe generally the system which already exists in Belgium.

3. An International Commission for fixing upon a standard of luminous intensity, to be used in measurements of electric lights, and for deciding upon the best methods of making such measurements.

The following recommendations have also been made by the Congress:—That the diameters of wires employed in telegraphy be stated in millimetres; that the cultivation of the gutta-percha tree be guarded by suitable regulations, to prevent this important product from becoming scarce; that the Governments of the different countries be requested to legislate on the subject of submarine cables, the present state of the law being insufficient to guarantee the rights of property in such cables.

In illustration of the present state of things Dr. C. W. Siemens mentioned a case where a cable which his firm had laid was wilfully cut by a captain who had caught it with his anchor in deep water, and the law afforded no remedy. It is also understood that regulations are to be made as to the repair of cables which are crossed by other cables belonging to a different company.

A further recommendation, that all countries should adopt for ships engaged in laying cables the same code of signals which is already in use in English ships was withdrawn upon the presentation of indubitable evidence that the code in question was adopted months ago in a note signed by the representatives of all the nations concerned.

[1] Continued from p. 533.

All the proceedings of the Congress have been conducted in French, and it was a novel sensation to most of us to see our English friends mount the tribune and deliver their sentiments in French; a still more novel sensation to those who for the first time ventured upon such an undertaking themselves. You first rise in your place and say, *Je demande la parole*, at the same time holding up your hand to catch the eye of the president. On his replying, *Vous avez la parole*, you walk from your place to the tribune, which is a raised platform in front of the audience, and there, with the eyes of the assembled *savans* of Europe fixed upon you, you must carry out your rash undertaking, with all your imperfections on your head. It is like the sensation of diving for the first time into deep water, where you must swim or drown.

In these international gatherings very wide deviations from the correct standards of grammar and pronunciation are indulgently tolerated, and the English have certainly not appeared to disadvantage as compared with the Germans; though it has been by no means a rare occurrence to see a speaker of either of these nations in sore straits for want of a word. There is one great advantage in conducting a Congress in a foreign tongue, and that is that the difficulty of the situation puts a wholesome check upon any tendency to verbiage on the part of a speaker; he is glad to express his meaning in the simplest manner that he can, and to desist as soon as his laborious task is accomplished; but this advantage is to some extent lost where, as on the present occasion, the language is the native tongue of half the members of the Congress. Some of the later sittings were decidedly dull and unprofitable, being mainly occupied with prolix dissertations of no general interest. The *Salle des Séances*, with its draped walls and high canvas roof, is very stifling to the voice, and much of what was said was insufficiently heard by the bulk of the audience.

The official reports of the proceedings were taken not by shorthand writers, but by young men skilled in science, who wrote abstracts of the speeches in longhand during their delivery; and it must be acknowledged that they did their work exceedingly well. The report thus taken of each meeting was printed and laid before the members at the next meeting, to be adopted before proceeding to any other business. It is called the *procès verbal*, and is treated like the minutes of an English meeting, but it is much fuller than our minutes usually are.

So much of these reports as relates to the discussions on units has been reprinted in the *Révue Scientifique*, No. 13. We have not observed reprints of any other discussions of the Congress.

The jury are now hard at work. They have divided themselves into six groups, which are subdivided into fourteen classes according to the first fourteen classes of the catalogue; and some of the more important of these classes have been still further subdivided; the total number of jurors being about 150, one-half of whom are French. By the help of this division of labour the official inspections of the exhibits have been, we believe, completed; but some days will be devoted to carrying out a series of experimental tests, which have already been commenced; and it is probable that some valuable data relative to electric lights and the machines which furnish their electricity will remain as one definite result of the present Exhibition.

In connection with these experiments a good story is told respecting resistance-coils. An eminent firm sent off several patterns of resistance-boxes to the Exhibition, but being out of one of their favourite types, they supplied its place by an empty box having exactly the outward appearance of the genuine article. As ill-luck would have it, the jury selected this particular box as being precisely what they wanted to assist them in their experiments, and asked for the loan of it. The representative on the spot, being ignorant of the sham, and appreciating the compliment paid to his house, lent the box with the utmost alacrity. The result can be better imagined than described. Application was then made to another eminent firm for a box which occupied a conspicuous position in their case of exhibits; and this also turned out to be a dummy, but the joke was not carried so far this time, as the representative in charge at once declared the fact.

(To be continued.)

NOTES

THE subscriptions received for the Rolleston Memorial Fund up to the present date amount to about 530*l*. It is hoped that this sum may shortly be considerably augmented, especially by subscriptions expected to be received from Oxford at the beginning of the present term. All promoters of the movement are requested to make its existence known to others likely to interest themselves in the matter. The treasurer is Mr. E. Chapman, of Frewen Hall, Oxford. A general meeting will shortly be held to determine finally the form which the memorial shall take.

SOON after the death of the late Prof. Rolleston, F.R.S., the delegates of the University Museum at Oxford, acting with the advice of Prof. W. H. Flower, F.R.S., requested Mr. Robertson and Mr. Hatchett Jackson of the Anatomical Department to set in order the collection of Crania in the Museum illustrating the various races of mankind. The compilation of the Catalogue has just been completed by Mr. Hatchett Jackson, and the specimens arranged in the cases by him and Mr. Robertson. The collation of the Catalogue and the numbering of the specimens will shortly be carried out by the latter gentleman. The method of arrangement is that adopted by Prof. Flower in the recently-issued Part I. of the Osteological Catalogue of Vertebrated Animals in the Museum of the Royal College of Surgeons. Students will consequently be enabled to compare with ease the Oxford collection with the collection in the Hunterian Museum. The numbers at Oxford range from 1 to 1053 approximately—a rather larger total than the corresponding section in Prof. Flower's Catalogue. The Oxford collection is peculiarly rich in English specimens of a date prior to the Conquest. There is a unique series of Crania from various Long Barrows; and from the Round Barrows of the Yorkshire Wolds, obtained by Canon Greenwell in his excavations and presented by him to the University, together with other specimens chiefly from cist burials of the late Bronze period. The Roman and Roman-British number 180; the Anglo-Saxon 96. The races of Ancient Egypt, of India with Ceylon, of New Zealand, the American Continent, and the various regions of Australia are well represented. There are five Tasmanian, seven Andamanese crania, and fine specimens of Zulus and Bushmen. There are besides large stores with which at present it has been found impossible to deal. And in the Catalogue as it stands are not included various skeletons and two sets of life-like casts—one set, replicas of those obtained in the voyage of the *Astrolabe* and presented many years ago to Dr. Acland, then Lee's Reader of Anatomy at Christ Church, by Prof. Milne-Edwards the elder; the other set, purchased in 1869, and representing various aboriginal tribes of Australia. It may be added that during the present Long Vacation, Miss Cracroft, niece of the late Lady Franklin, has presented to the Anatomical Department fourteen portraits of Tasmanian aborigines, authenticated with the names of the individuals, their ages, and the districts whence they came, and admirably executed in water colour by Bock.

AT a public meeting of the University College (London) Chemical and Physical Society, to be held on Friday, October 21, at 7 p.m., Prof. Alex. W. Williamson, Ph.D., LL.D., F.R.S., will deliver an address on "An Error in the Commonly-accepted Theory of Chemistry."

WE regret to learn from the *American Naturalist* of the death of Mr. Carlile P. Patterson, Superintendent of the U.S. Coast Survey. It is supposed that Mr. Julius E. Hilgard, for a long time second officer of the Survey, will be promoted to the vacant post.

MR. ETHERIDGE, F.G.S., is, we are informed, leaving the Geological Survey to be Assistant-Keeper of the Geological Department at the British Museum of Natural History, South Kensington.

THE meeting of the Iron and Steel Institute being held in London this week is probably the most interesting and important since the Institute was founded. Representatives of nearly every foreign Government are present, and the muster of foreign members is unusually large. Several of the papers are of great practical and even scientific interest, and are sure to attract much attention and give rise to discussion. On Tuesday visits were paid to Messrs. Siemens' works at Woolwich, and to the Victoria Docks, and in the evening the Lord Mayor entertained the Institute at dinner. Yesterday afternoon a visit was made to Woolwich Arsenal, and in the evening the annual dinner of the Institute was held at Willis's Rooms. To-day the Small-Arms Factory at Enfield is to be visited, and the Carriage Works of the Great Eastern Railway at Stratford, and in the evening a *conversazione* will be held at South Kensington Museum. To-morrow will be devoted to a visit to Newhaven and Brighton.

THE scientific lecturers this winter at the London Institution, Finsbury Circus, will be Mr. Grant Allen ("An English Weed"); Prof. H. E. Armstrong, F.R.S. ("The Economical Use of Coal-gas for Lighting and Heating"); Prof. W. E. Ayrton, F.R.S. ("The Storage of Power"); Prof. R. S. Ball, F.R.S. ("Comets"); Dr. Lionel S. Beale, F.R.S. ("A Living Particle"); Prof. R. Bentley ("Materials used for Paper"); Dr. James Geikie, F.R.S. ("The Ancient Glacier-systems of Europe"); Prof. J. W. Judd, F.R.S. ("Are there Coal-fields under London?"); Prof. E. Ray Lankester, F.R.S. ("Scorpions, Terrestrial and Marine"); Prof. O. J. Lodge ("Electricity *versus* Smoke"); Mr. John Perry ("Spinning-tops"); Dr. W. H. Stone ("Singing, Speaking, and Stammering"); Mr. James Sully ("The Causation and Phænomena of Dreams"); and the Rev. J. G. Wood ("The Horse's Hoof").

A LETTER was read at the recent Social Science meeting at Saratoga from Mr. Charles Darwin to Mrs. Emily Talbot, in response to her inquiries as to the investigation of the mental and bodily development of infants. He specifies points of inquiry which it seems to him possess some scientific interest. "Does the education of the parents, for instance, influence the mental powers of their children at any age, either at a very early or somewhat more advanced stage? This could perhaps be learned by schoolmasters or mistresses, if a large number of children were first classed according to age and their mental attainments, and afterwards in accordance with the education of their parents, as far as this could be discovered. As observation is one of the earliest faculties developed in young children, and as this power would probably be exercised in an equal degree by the children of educated and uneducated persons, it seems not impossible that any transmitted effect from education would be displayed only at a somewhat advanced age. It would be desirable to test statistically, in a similar manner, the truth of the often-repeated statement that coloured children at first learn as quickly as white children, but that they afterwards fall off in progress. If it could be proved that education acts not only on the individual, but by transmission on the race, this would be a great encouragement to all working on this all-important subject. It is well known that children sometimes exhibit at a very early age strong special tastes, for which no cause can be assigned, although occasionally they may be accounted for by reversion to the taste or occupation of some progenitor; and it would be interesting to learn how far such early tastes are persistent and influence the future career of the individual. In some instances such tastes die away without apparently leaving any after effect; but it would be desirable to know how far this is commonly the case, as we should then know whether it were important to direct, as far as this is possible, the early tastes of our children. It may be more beneficial that a child should follow energetically some pursuit, of however trifling a nature, and thus acquire perseverance, than that he should be turned from it, because of no future advantage to him. I will mention one other small point of inquiry in relation to very young children, which may possibly prove important with respect to the origin of language, but it could be investigated only by persons possessing an accurate musical ear: children, even before they can articulate, express some of their feelings and desires by noises uttered in different notes. For instance, they make an interrogative noise, and others of assent and dissent in different tones, and it would, I think, be worth while to ascertain whether there is any uniformity in different children in the pitch of their voices under various frames of mind."

IN a letter to the *Madras Mail* of September 8 on the use of gigantic sea-weed as a protective agent for shores, Capt. J. H. Taylor, the Master-Superintendent of Madras, gives the following interesting "sea-serpent" story:—"A notable incident connected with this sea-weed, is recalled to my recollection, by Dr. Furnell's letter. About fifteen years ago, while I was in my ship at anchor in Table Bay, an enormous monster, as it appeared, was seen drifting, or advancing itself round Green Point, into the Harbour. It was more than one hundred feet in length, and moved with an undulating snake-like motion. Its head was crowned with what appeared to be long hair, and the keen-sighted among the affrighted observers declared they could see its eyes and distinguish its features. The military were called out, and a brisk fire poured into it at a distance of about five hundred yards. It was hit several times, and portions of it knocked off. So serious were its evident injuries, that on its rounding the point it became quite still, and boats went off to examine it and complete its destruction. It was found to be a specimen of the sea-weed above mentioned, and its stillness after the grievous injuries inflicted was due to its having left the ground swell and entered the quiet waters of the Bay."

DR. B. W. RICHARDSON is about to continue the series of lectures delivered by him in the spring at the instance of the "Ladies' Sanitary Association," of Berners Street. The lectures are devoted generally to the subject of "Domestic Sanitation." In the forthcoming series, which will be commenced in the Lower Hall, Exeter Hall, on Saturday, the 22nd inst., the structure and functions of the nervous system, and the physical and mental training of the young, will occupy a prominent place.

THE Phylloxera Congress, to which we have already referred, was opened on Sunday at Bordeaux.

THE Rev. J. Hoskyns-Abrahall writes to the *Times* from Combe, near Woodstock, October 3:—"On October 1, about 8.42 p.m., when I was walking in a north-westerly direction, about three hundred yards north-west of Hanborough Station, which is three-quarters of a mile north-west of Oxford, the eastern sky was suddenly flooded with a light that vied with that of the moon, which shone more than half full in the west. Turning round, I beheld a magnificent meteor, of a pale yellow hue, descending with a slow motion, vertically. It seemed larger than Jupiter. When I first saw it, it had dropped about a third of the distance from the zenith to the horizon; after traversing another third of that space it burst without scattering any sparks."

THE Exhibition of the Photographic Society is now open at the rooms of the Old Water-Colour Society in Pall Mall.

A NEW form of compressed air locomotive engine, the invention of a Mr. Hardie, has been put to a practical, and, it is said, successful test in New York, on the Second Avenue elevated railroad. The compressed air is stored in four tubular tanks connected with each other by pipes so as virtually to form one large reservoir. It is said that a saving of 50 per cent. is effected on the cost of working a locomotive by the use of the new invention.

A TELEGRAM from Geneva last Thursday states that another large rift has opened in the Tschingel, a circumstance which indicates that the mountain is still in movement. The inhabitants of Elm, many of whom had returned, have been again warned to leave their houses.

WE have received a very interesting coloured picture of the moon, reproduced from a telescopic painting by Mr. Henry Harrison of New York. It is the first of a series, and represents the moon at the stage of the three days crescent. The picture is twenty-four inches square, with the moon eighteen inches in diameter, and the execution is excellent. It shows the earth-shine very distinctly on the surface in shadow. As to its accuracy, we notice from a letter by Prof. Harkness that it was tested at the United States Naval Observatory, and the result is stated to have been all that could be desired. This picture is to be followed up by five others representing the moon at various succeeding stages. The London agent for the picture is Mr. William Wesley.

THE June number of the *Journal* of the Straits Branch of the Royal Asiatic Society, published half-yearly (London : Trübner and Co.) contains several useful articles :—Some account of the mining districts of Lower Pérak, by J. Errington de la Croix; The Folklore of the Malays, by W. E. Maxwell; Notes on the Rainfall of Singapore, by J. J. L. Wheatley; Journal of a voyage through the Straits of Malacca on an expedition to the Molucca Islands, by Capt. Walter Caulfield Lennox; a sketch of the career of James Richardson Logan, by J. Turnbull Thomas; and a memorandum on the various tribes inhabiting Penang and Province Wellesley, by J. R. Logan. A journal with such a programme deserves every encouragement, and we hope it will receive it.

THE Society for Promoting Christian Knowledge has issued a series of coloured zoological diagrams representing various typical specimens of animal life, from corals and anemones to mammals. They are accurately and nicely executed after Leutemann's Zoological Atlas for Schools. Why should we still have to go to Germany for such productions?

UNDER the title of "Anglo-Saxon Britain" Mr. Grant Allen has published (through the S.P.C.K.) an interesting little volume on the early history of England. He has taken pains to master all the results of recent research in archæology and ethnology, and therefore the book has a more scientific flavour than usual with such works. While adopting generally the views associated with the names of Freeman and Green, he shows independence of view, and treats his subject in an unusually unconventional manner. Either as a reading-book or as a text-book for the special period, it ought to be useful; it is certainly interesting.

IN "Miscellanies of Animal Life," by Elizabeth Spooner (S.P.C.K.), the authoress has brought together a number of interesting and instructive extracts from various good authorities as to the habits of animals, which ought to prove interesting to children.

THE double balloon ascent which we announced in our last number took place at La Villette gasworks on Wednesday last week, at the appointed time. The weather was splendid, and the two balloons were in view for some length of time; but the noise produced by the crackling of the net and the swinging of the aërostat produced such an effect on the sculler that he desisted from his experiment, and contented himself after a few pulls with an ordinary ascent. The experiment will be tried shortly with more experienced aëronauts.

ON October 18 a great electrical experiment will be made at the Paris Opera to test the effect of electric light on theatrical representations. The principal feature will be the lighting of a large number of Brush lamps by a magneto-electric machine revolving in the Palais de l'Industrie.

THE Ashton-under-Lyne Linnæan Botanical Society held its annual meeting on Sunday, October 2. Its members belong almost exclusively to the artisan class, and they are doing very good work. Under the auspices of the Ashton Biological Society they have undertaken the preparation of a complete flora and fauna of the district. The annual report gives particulars of the winter meetings and summer rambles of the members. It is a remarkable and interesting fact that the science of botany has been steadily and successfully cultivated by the Lancashire artisans for a century, if not longer, and their meetings, which are numerous, are held upon the Sundays.

ALL our lady readers are familiar with the name of Pullar of Perth, whose practical application of science to dyeing seems to meet with general favour. The present representative of that firm, Mr. Robert Pullar, is evidently conscious of how much he owes to science, and has recently been endeavouring to make her some return. The name of the Perthshire Natural History Society is no doubt known to many of our readers; its present president is Dr. James Geikie. At a recent meeting of the Society Mr. Pullar handed over to the Society a handsome and commodious house for their use, with accommodation for a museum, &c., Mr. Pullar himself having been the principal subscriber to the fund. The building will be known as the Moncrieffe Memorial Museum, in memory of the late president of the Society, Sir Thomas Moncrieffe. We trust, under the favourable conditions in which it now finds itself, the Perthshire Natural History Society will do even better work than it has hitherto done, and that its museum will become a model of what a local museum ought to be.

MR. J. HARRIS STONE, M.A., will contribute to the November number of *Good Words* an article upon the Viking Ship which was recently discovered in Norway. The paper will be illustrated with woodcuts made from photographs taken by the author.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus erythræus*) from India, presented by Mr. Frank Smyth; two Beautiful Parrakeets (*Psephotus pulcherrimus*), an Australian Quail (*Synœcus australis*), a Regent Bird (*Sericulus melinus*), three Modest Grass Finches (*Amadina modesta*) from Australia, two Banded Grass Finches (*Pœphila cincta*), two Bichenos Finches (*Estrelda bichenovii*) from Queensland, a Melodious Finch (*Phonipara canora*) from Cuba, a Blue-beaked Weaver Bird (*Spermospiza hæmatina*) from West Africa, a Black-headed Finch (*Munia malacca*) from India, two Ceylonese Hanging Parrakeets (*Loriculus asiaticus*) from Ceylon, presented by Mr. T. H. Bowyer Bower; two Dunlins (*Tringa cinclus*), a Ringed Plover (*Œgialitis hiaticula*), British, presented by Mr. Edmund A. S. Elliot, M.R.C.S.; a Common Viper (*Vipera berus*, var.), British, presented by Mr. L. A. Sandford; two Axolotls (*Siredon mexicanus*) from Mexico, presented by Dr. Heneage Gibbes, F.Z.S.; a Leopard Tortoise (*Testudo pardalis*) from South Africa, a Radiated Tortoise (*Testudo radiata*) from Madagascar, three Bell's Cinixys (*Cinixys belliana*) from Angola, presented by Sir John Kirk, C.M.Z.S.; a Hog Deer (*Cervus porcinus*), a Hybrid Mesopotamian Fallow

Deer (between *Cervus mesopotamicus* ♂, and *Cervus dama* ♀), a Hybrid Muntjac (between *Cervulus lacrymans* ♂, and *Cervulus muntjac* ♀), born in the Gardens.

GEOGRAPHICAL NOTES

THE U.S. steamer *Corwin*, which has been searching for the missing, and we fear lost, *Jeannette*, has succeeded in reaching Wrangel Land, which has been annexed to the United States. We learn that it is probable that an international effort will be made next year to find traces of the *Jeannette;* our own Government has been moved in the matter, and may very possibly fit out a vessel for the purpose.

THE French Geographical Society has received intelligence of the assassination of a young explorer, M. Henri Dufour, by a tribe of the Ovambos, now at war with the Portuguese. M. Dufour left Omoruru in company with some merchants in December last for the purpose of exploring the basin of the River Cumene, in Eastern Africa. On arriving at this river his companions deemed it expedient to abandon the enterprise, on which M. Dufour courageously resolved to continue his course alone. No tidings of him having reached Omoruru, an inquiry was instituted, which led to the discovery of his untimely end. M. Dufour's papers and effects have been found, but his body has not yet been recovered.

THE current number of the Geographical Society's *Proceedings* is chiefly remarkable for a very long instalment of the report of papers read at the Geographical Section of the British Association, including Sir J. Hooker's address, Sir R. Temple's paper on Asia, and Sir F. J. Evans' on maritime discovery. The paper of this month's number is one by Dr. Bell, of the Geological Survey of Canada, on the commercial importance of Hudson's Bay, with remarks on recent surveys and explorations, which is accompanied by a large and carefully drawn map of the region. The most important of the geographical notes are those respecting Mr. J. M. Schuver's journey in Africa and the proposition of the British Association that the Geographical Society should undertake a scientific expedition to Kilinnandjaro and Mount Kenia, with a subsidy of one hundred pounds. Another note records the presence of the first British traveller at Hami, but seemingly his name and plans are alike a mystery.

WITH reference to the recent census of India the *Pioneer* learns that the census returns show a grand total of population for all India of 252,000,000. Figures amounting to 218,000,000 can be compared with previous censuses, and show an increase of 6·2 per cent. But in some provinces apparent large increases may be due to the inaccuracy of previous enumerations. Provincial totals are—Bengal, 68,800,000; Assam, 4,800,000; Madras, 30,800,000; Bombay, 13,900,000; ditto Native States, 6,900,000; Sind, 2,400,000; North-West Provinces, 32,600,000; ditto Native States, 700,000; Oudh, 11,400,000; British Punjab, 18,700,000; Native ditto, 3,800,000; Central Provinces, 11,500,000; Berar, 2,600,000; British Burmah, 3,700,000; Mysore, 4,100,000; Rajpootana, 11,000,000; Central India, 9,200,000; Hyderabad, 9,100,000. The total makes males 123,000,000, females 118,000,000. The provincial increases per cent. as compared with previous censuses, are as follows:—Bengal, 10; Assam, 19; Sind, 10; North-West, 6; Oudh, 1; Punjab, 7; Central Provinces, 25; Berar, 20; Burmah, 35. The decreases are—Madras, 2·4 per cent.; Bombay, ·3; Mysore, 17.

A SOMEWHAT curious boat has been built and launched at Granton, N.B., for use by the Rev. T. J. Comber, of the Baptist expedition on the Congo. With a view to its being at once portable and durable, this boat has been made of canvas, coated with a mixture of lampblack and tar, and is stretched into shape by malacca canes, while the interior consists of three movable umbrella-shaped structures, which can be tightened at will; it has a partly-covered deck, and weighs only 60 lbs.; further, it can be easily taken to pieces, so as to be carried by two persons, and by a little arrangement will form a tent.

Petermann's Mittheilungen for October is filled up with two articles—one by Mr. W. H. Dall, on the hydrology of Behring Sea and neighbouring waters, and Hofrath A. Regel's account of his expedition to Turfan in 1879.

MESSRS. BLACKWOOD have issued a tenth edition of Page's "Introductory Text-Book of Physical Geography," revised and enlarged by Prof. Lapworth, of the Mason College, Birmingham.

CAPT. POPELIN, of the Belgian station at Karema, Lake Tanganyika, whose death was lately announced, appears to have died when on his way from Ujiji to the Mampara district, in Southern Uguha.

ON SOME APPLICATIONS OF ELECTRIC ENERGY TO HORTICULTURE AND AGRICULTURE [1]

ON the 1st of March, 1880, I communicated to the Royal Society a paper "On the Influence of Electric Light upon Vegetation, &c.," in which I arrived at the conclusion that electric light was capable of producing upon plants effects comparable to those of solar radiation; that chlorophyll was produced by it, and that bloom and fruit, rich in aroma and colour, could be developed by its aid. My experiments also went to prove that plants do not as a rule require a period of rest during the twenty-four hours of the day, but make increased and vigorous progress if subjected (in winter time) to solar light during the day and to electric light during the night.

During the whole of last winter I continued my experiments on an enlarged scale, and it is my present purpose to give a short account of these experiments, and of some further applications of electric energy to farming operations (including the pumping of water, the sawing of timber, and chaff and root-cutting) at various distances, not exceeding half a mile from the source of power, giving useful employment during the daytime to the power-producing machinery, and thus reducing indirectly the cost of the light during the night-time.

The arrangement consists of a high-pressure steam-engine of 6 horse-power nominal, supplied by Messrs. Tangye Brothers, which gives motion to two dynamo-machines (Siemens D), connected separately to two electric lamps, each capable of emitting a light of about 5000 candle-power. One of these lamps was placed inside a glass house of 2318 cubic feet capacity, and the other was suspended at a height of 12 to 14 feet over some sunk greenhouses. The waste steam of the engine was condensed in a heater, whence the greenhouses take their circulating supply of hot water, thus saving the fuel that would otherwise be required to heat the stoves.

The experiments were commenced on October 23, 1880, and were continued till May 7, 1881. The general plan of operation consisted in lighting the electric lights, at first at 6 o'clock, and during the short days at 5 o'clock every evening except Sunday, continuing their action until dawn.

The outside light was protected by a clear glass lantern, whilst the light inside the house was left naked in the earlier experiments, one of my objects being to ascertain the relative effect of the light under these two conditions. The inside light was placed at one side over the entrance into the house, in front of a metallic reflector, to save the rays that would otherwise be lost to the plants within the house.

The house was planted in the first place with peas, French beans, wheat, barley, and oats, as well as with cauliflowers, strawberries, raspberries, peaches, tomatoes, vines, and a variety of flowering plants, including roses, rhododendrons, and azaleas. All these plants being of a comparatively hardy character, the temperature in this house was maintained as nearly as possible a 60° Fahr.

The early effects observed were anything but satisfactory While under the influence of the light suspended in the open ai over the sunk houses the beneficial effects due to the electric light, observed during the previous winter, repeated themselves, the plants in the house with the naked electric light soon manifested a withered appearance. Was this result the effect of the naked light, or was it the effect of the chemical products—nitrogenous compounds and carbonic acid—which are produced in the electric arc?

Proceeding on the first named assumption, and with a view of softening the ray of the electric arc, small jets of steam were introduced into the house through tubes, drawing in atmospheric air with the steam, and producing the effect of clouds interposing themselves in an irregular fashion between the light and the plants. This treatment was decidedly beneficial to the plants, although care had to be taken not to increase the amount of moisture thus intro-

[1] Paper read at the British Association by C. William Siemens, D.C.L. LL.D., F.R.S., M. Inst. C.E.

duced beyond certain limits. As regards the chemical products it was thought that these would prove rather beneficial than otherwise, in furnishing the very ingredients upon which plant-life depends, and further that the constant supply of pure carbonic acid resulting from the gradual combustion of the carbon electrodes might render a diminution in the supply of fresh air possible, and thus lead to economy of fuel. The plants did not, however, take kindly to these innovations in their mode of life, and it was found necessary to put a lantern of clear glass round the light, for the double purpose of discharging the chemical products of the arc, and of interposing an effectual screen between the arc and the plants under its influence.

The effect of interposing a mere thin sheet of clear glass between the plants and the source of electric light was most striking. On placing such a sheet of clear glass so as to intercept the rays of the electric light from a portion only of a plant, for instance a tomato plant, it was observed that in the course of a single night the line of demarcation was most distinctly shown upon the leaves. The portion of the plant under the direct influence of the naked electric light, though at a distance from it of nine to ten feet, was distinctly shrivelled, whereas that portion under cover of the clear glass continued to show a healthy appearance, and this line of demarcation was distinctly visible on individual leaves. Not only the leaves, but the young stems of the plants soon showed signs of destruction when exposed to the naked electric light, and these destructive influences were perceptible, though in a less marked degree, at a distance of twenty feet from the source of light. A question here presents itself that can hardly fail to excite the interest of the physiological botanist. The clear glass does not apparently intercept any of the luminous rays, which cannot therefore be the cause of the destructive action. Prof. Stokes showed, however, in 1853, that the electric arc is particularly rich in highly refrangible invisible rays, and that these are largely absorbed in their passage through clear glass; it therefore appears reasonable to suppose that it is those highly refrangible rays beyond the visible spectrum that work destruction on vegetable cells, thus contrasting with the luminous rays of less refrangibility, which, on the contrary, stimulate their organic action.

Being desirous to follow up this inquiry a little further, I sowed a portion of the ground in the experimental conservatory with mustard and other quick-growing seeds, and divided the field into equal radial portions by means of a framework, excluding diffused light, but admitting light at equal distances from the electric arc. The first section was under the action of the naked light, the second was covered with a pane of clear glass, the third with yellow glass, the fourth with red, and the fifth with blue glass. The relative progress of the plants was noted from day to day, and the differences of effect upon the development of the plants was sufficiently striking to justify the following conclusions: — Under the clear glass the largest amount of and most vigorous growth was induced; the yellow glass came next in order, but the plants, though nearly equal in size, were greatly inferior in colour and thickness of stem to those under the clear glass; the red glass gives rise to lanky growth and yellowish leaf, while the blue glass produces still more lanky growth and sickly leaf. The uncovered compartment showed a stunted growth with a very dark and partly shrivelled leaf. It should be observed that the electric light was kept on from five p.m. till six a.m. every night except Sundays during the experiment, which took place in January, 1881, but that diffused daylight was not excluded during the intervals; also that circulation of air through the dividing framework was provided for.

These results are confirmatory of those obtained by Dr. J. W. Draper[1] in his valuable researches on plant cultivation in the solar spectrum in 1843, which led him to the conclusion, in opposition to the then prevailing opinion, that the yellow ray, and not the violet ray, was most efficacious in promoting the decomposition of carbonic acid in the vegetable cell.

Having, in consequence of these preliminary inquiries, determined to surround the electric arc with a clear glass lantern, more satisfactory results were soon observable. Thus, peas which had been sown at the end of October produced a harvest of ripe fruit on February 16, under the influence, with the exception of Sunday nights, of continuous light. Raspberry stalks put into the house on December 16 produced ripe fruit on March 1, and strawberry plants put in about the same time produced ripe fruit of excellent flavour and colour on February 14. Vines which broke on December 26 produced ripe grapes of stronger flavour than usual on March 10. Wheat, barley, and oats shot up with extraordinary rapidity under the influence of continuous light, but did not arrive at maturity; their growth, having been too rapid for their strength, caused them to fall to the ground, after having attained the height of about twelve inches.

Seeds of wheat, barley, and oats, planted in the open air and grown under the influence of the external electric light, produced, however, more satisfactory results; having been sown in rows on January 6, they germinated with difficulty, on account of frost and snow on the ground, but developed rapidly when milder weather set in, and showed ripe grain by the end of June, having been aided in their growth by the electric light until the beginning of May.

Doubts have been expressed by some botanists whether plants grown and brought to maturity under the influence of continuous light would produce fruit capable of reproduction, and in order to test this question the peas gathered on February 16 from the plants which had been grown under almost continuous light action were replanted on February 18. They vegetated in a few days, showing every appearance of healthy growth.

Further evidence on the same question will be obtained by Dr. Gilbert, F.R.S., who has undertaken to experiment upon the wheat, barley, and oats grown as above stated; but still more evidence will probably be required before all doubt on the subject can be allayed.

I am aware that the great weight of the opinion of Dr. Darwin goes in favour of the view that many plants, if not all of them, require diurnal rest for their normal development. In his great work on "The Movements of Plants" he deals in reality with plant life, as it exists under the alternating influence of solar light and darkness; he investigates with astonishing precision and minuteness their natural movements of circumnutation and nightly or nyctitropic action, but does not extend his inquiries to the conditions resulting from continuous light. He clearly proves that nyctitropic action is instituted to protect the delicate leaf-cells of plants from refrigeration by radiation into space, but it does not follow, I would submit, that this protecting power involves the necessity of the hurtful influence. May it not rather be inferred from Dr. Darwin's investigations that the absence of light during night-time involved a difficulty to plant life that had to be met by special motor organs, which latter would perhaps be gradually dispensed with by plants if exposed to continual light for some years or generations?

It is with great diffidence, and without wishing to generalise, that I feel bound to state as the result of all my experiments, extending now over two winters, that although periodic darkness evidently favours growth in the sense of elongating the stalks of plants, the continuous stimulus of light appears favourable for healthy development at a greatly accelerated pace, through all the stages of the annual life of the plant, from the early leaf to the ripened fruit. The latter is superior in size, in aroma, and in colour to that produced by alternating light, and the resulting seeds are not at any rate devoid of regerminating power.

Further experiments are necessary, I am aware, before it would be safe to generalise, nor does this question of diurnal rest in any way bear upon that of annual or winter rest, which probably most plants, that are not so-called annuals, do require.

The beneficial influence of the electric light has been very manifest upon a banana palm, which at two periods of its existence, viz., during its early growth and at the time of the fruit development, was placed (in February and March of 1880 and 1881) under the night action of one of the electric lights, set behind glass at a distance not exceeding two yards from the plant; the result was a bunch of fruit weighing 75 pounds, each banana being of unusual size, and pronounced by competent judges to be unsurpassed in flavour. Melons also, remarkable for size and aromatic flavour, have been produced under the influence of continuous light in the early spring of 1880 and 1881, and I am confident that still better results may be realised when the best conditions of temperature and of proximity to the electric light have been thoroughly investigated.

My object hitherto has rather been to ascertain the general conditions necessary to promote growth by the aid of electric light than the production of quantitative results; but I am disposed to think that the time is not far distant when the electric light will be found a valuable adjunct to the means at the disposal of the horticulturist, in making him really indepen-

[1] See "Scientific Memoirs" by J. W. Draper, M.D., LL.D. Memoir X.

dent of climate and season, and furnishing him with a power of producing new varieties.

Before electro-horticulture can be entertained as a practical process it would be necessary however to prove its cost, and my experiments of last winter were in part directed towards that object. Where water-power is available, the electric light can be produced at an extremely moderate cost, comprising carbon electrodes, and wear and tear of and interest upon apparatus and machinery employed, which experience elsewhere has already shown to amount to 6*d*. per hour for a light of 5000 candles. The personal current attention requisite in that case consists simply in replacing the carbon electrodes every six or eight hours, which can be done without appreciable expense by the under-gardener in charge of the fires of the greenhouses.

In my case no natural source of power was available, and a steam-engine had to be resorted to. The engine of 6 normal horse-power which I employ to work the two electric lights of 5000 candle-power each, consumes 56 lbs. of coal per hour (the engine being of the ordinary high-pressure type), which, taken at 20*s*. a ton, would amount to 6*d*. or to 3*d*. per light of 5000 candles. But against this expenditure has to be placed the saving of fuel effected in suppressing the stoves for heating the greenhouses, the amount of which I have not been able to ascertain accurately, but it may safely be taken at two-thirds of the cost of coal for the engine, thus reducing the cost of the fuel per light to 1*d*. per hour; the total cost per light of 5000 candles will thus amount to 6*d*. + 1*d*. = 7*d*. per hour.

This calculation would hold good if the electric light and engine power were required during say twelve hours *per diem*, but inasmuch as the light is not required during the daytime, and the firing of the boiler has nevertheless to be kept up in order to supply heat to the greenhouses, it appears that during the daytime an amount of motive-power is lost equal to that employed during the night.

In order to utilise this power I have devised means of working the dynamo-machine also during the daytime, and of transmitting the electric energy thus produced by means of wires to different points of the farm, where such operations as chaff-cutting, swede-slicing, timber-sawing, and water-pumping have to be performed.

These objects are accomplished by means of small dynamo-machines placed at the points where power is required for these various purposes, and which are in metallic connection with the current-generating dynamo-machine near the engine. The connecting wires employed consist each of a naked strand of copper wire supported on wooden poles or on trees without the use of insulators, whilst the return-circuit is effected through the park-railing or wire fencing of the place, which is connected with both transmitting and working machines by means of short pieces of connecting wire. In order to insure the metallic continuity of the wire fencing, care has to be taken wherever there are gates to solder a piece of wire, buried below the gate, to the wire fencing on either side.

As regards pumping the water, a 3-horse-power steam-engine was originally used, working two force-pumps of 3½-inch diameter, making thirty-six double strokes per minute. The same pumps are still employed, being now worked by a dynamo-machine weighing 4 cwt. When the cisterns at the house, the gardens, and the farm require filling, the pumps are started by simply turning the commutator at the engine station, and in like manner the mechanical operations of the farm already referred to are accomplished by one and the same prime mover.

It would be difficult in this instance to state accurately the percentage of power actually received at the distant station, but in trying the same machines under similar circumstances of resistance with the aid of dynamometers, as much as 60 per cent. has been realised.

In conclusion, I have pleasure to state that the working of the electric light and transmission of power for the various operations just named are entirely under the charge of my head-gardener, Mr. Buchanan, assisted by the ordinary staff of under-gardeners and field-labourers, who probably before never heard of the power of electricity.

Electric transmission of power may eventually be applied also to thrashing, reaping, and ploughing. These objects are at the present time accomplished to a large extent by means of portable steam-engines, a class of engine which has attained a high degree of perfection; but the electric motor presents the great advantage of lightness, its weight per horse-power being only 2 cwt., whilst the weight of a portable engine with its boiler filled with water may be taken at 15 cwt. per horse-power. Moreover, the portable engine requires a continuous supply of water and fuel, and involves skilled labour in the field, whilst the electrical engine receives its food through the wire (or a light rail upon which it may be made to move about) from the central station, where power can be produced at a cheaper rate of expenditure for fuel and labour than in the field. The use of secondary batteries may also be resorted to with advantage to store electrical energy when it cannot be utilised.

In thus accomplishing the work of a farm from a central-power station, considerable savings of plant and labour may be effected; the engine-power will be chiefly required for day work, and its night work for the purposes of electro-horticulture will be a secondary utilisation of the establishment, involving little extra expense. At the same time the means are provided of lighting the hall and shrubberies in the most perfect manner, and of producing effects in landscape gardening that are strikingly beautiful.

THE ELECTRICAL DISCHARGE, ITS FORMS AND ITS FUNCTIONS[1]

II.

AMONG the various circumstances which combine to determine the character of the discharge, one of the most important is the size of the negative terminal. And in this respect, as well as in others, the negative differs fundamentally from the positive. If the negative be small, not so much in comparison with the positive as in absolute magnitude, and perhaps also in reference to the diameter of the tube, the tube will offer great "resistance," as it is termed, to the passage of the discharge. On the other hand, if the negative be large, the discharge passes with comparative ease. In the first case, even when the discharge passes, striæ are formed only with difficulty, if at all; in the second they are readily formed. This may easily be shown by using a tube with one small and one large terminal, which can be used alternately as positive and as negative; or by a tube having a negative terminal of variable length.

The same dependence of striation upon the size of the negative may be shown in the case of a tube with a negative terminal of barely sufficient size. In this case, if the tube be touched by the hand (an operation which, as will be hereafter explained, is equivalent to enlarging the negative), striæ will be brought out clear and distinct, while without this assistance they appear only in a confused and irregular manner.

Other characteristic features of the negative terminal would deserve our attention if time permitted. Thus, the well-known phenomena of the so-called "Holtz tube" (or tube divided into compartments by diaphragms furnished with narrow pipes leading from one compartment to the next, and all pointed in one direction), show that a small aperture will serve as a negative, but not as a positive terminal. This property has been generalised by Goldstein, who, using as a negative terminal a cylinder of non-conducting substance pierced with fine holes, reproduces all the phenomena appertaining to an ordinary metallic negative.

And, even apart from the phenomena of vacuum tubes, it would not be difficult to adduce instances showing the importance of the size of the negative terminal in electrical discharges generally. Of these I will now mention only the latest. In making some modifications of Planté's battery M. de Pozzer has found that, if the negative electrode be made of a plate of lead of half a millimetre in thickness, and the positive of one of two-thirds of a millimetre, but the former double the size of the latter, great advantage arises from the greater size of the negative. The discharge from a battery having a negative double as large as the positive lasted, on an average of several experiments, for an hour; while that from a battery, in which the sizes of the electrodes were reversed, lasted only half an hour. The effect of a battery with electrodes of equal size appears to have been intermediate to that of the two others.

From these phenomena, and especially from those of the moving terminal, as well as from other considerations, it appears that the general configuration of the discharge is mainly determined at the negative terminal.

In order, however, to experiment with any hope of progress

[1] A Lecture delivered before the British Association at York on September 5, 1881, by William Spottiswoode, D.C.L., LL.D., President of the Royal Society. Continued from p. 551.

in our knowledge of the nature and *modus operandi* of the discharge, we ought to be in a position to modify the discharge, so as to compare it under different circumstances. The methods hitherto usually employed for this object have been an alteration in the gas used, an alteration of the pressure, and a diversity of figure in the tube or in its terminals. Of the general character of the changes due to such alterations we have already seen something. But, besides these alterations, which are of a structural or instrumental character, it is also desirable to operate on a discharge actually *in transitu*. One of the methods, in fact the only one, employed until lately is that of the magnet, which was used as long ago as the time of Grove, Plücker, and other early experimenters. It is well known that a magnet will displace a movable conductor when carrying a current, according to laws established by Ampère. The same is true, in general terms, with respect to a discharge traversing an exhausted tube.

Thus, in the tube now before you, you will see that when one pole of a magnet is presented to the tube, the discharge is thrown to one side of the tube; and when the other pole is so presented the discharge is thrown to the other side. These two main features, however, very inadequately describe the actions of a magnet, which in fact operates separately not only upon each stria as a unit, but even upon the various parts of a stria in such a way as to deform it as well as to displace it. But they involve the main characteristics of the magnetic action, and must suffice on the present occasion to show that in the magnet we have a powerful instrument for examining the properties and functions of the discharge, even (if the term may be permitted) in the living specimen.

The other principal mode of operating on the discharge consists in reducing it to what has been called the "sensitive state"; *i.e.* to a state in which the position of the luminosity is affected by the approach of a conductor to the tube. For the details of an experimental investigation into the phenomena of this state, and a discussion of the conclusions that may be drawn therefrom, the reader is referred to the *Philosophical Transactions* of 1879 and 1880. But the following remarks may serve to convey some notion of the method and its issues. Sensitiveness is produced by breaking the circuit with a short interval of air, or, as it is usually described, by interposing an "air-spark" in one branch of the circuit, viz. either that leading from the positive, or in that leading from the negative, terminal of the machine to the tube, or by otherwise rendering the discharge intermittent. The effect of this is to discharge the electricity discontinuously, so that from time to time there passes into the tube a comparatively large quantity of electricity at a higher tension than would otherwise be the case. By this means the gas in the interior of the tube, or perhaps the interior surface of the tube itself, becomes momentarily charged with electricity, thus creating an electric tension, which may be discharged or "relieved" by a displacement in the electricity on a conductor brought near, or in contact with, the tube. This causes or permits a discharge from the interior of the tube itself of the electricity of an opposite kind to that with which the tube itself is charged. If the air spark is on the positive side the charge on the tube is positive, and the relief negative, and *vice versâ*. From this it follows, as might have been expected, that the effect of the relief on the visible discharge is different in the two cases. In each case the part of the inner surface of the tube nearest to the conductor acts as a *quasi* terminal. As a general rule, with a positive air-spark, the relief, being negative, tends to produce a dark space, and thereby gives the appearance of a repulsion of the luminous column. With a negative air-spark the relief, being positive, tends to produce a stria; it thereby causes luminosity, and gives an appearance of attraction of the luminous column.

The appearance of the luminous column when produced under the action of an air-spark is usually amorphous or unstratified, although this is not always the case. In the case of a positive air-spark the column is more or less constricted and confined to the central part of the tube; in the case of a negative air-spark it is more diffused, and usually fills the whole diameter of the tube. This is doubtless due to a gradual discharge from the sides of the tube, and is in accordance with what has been said above.

Under suitable circumstances this relief discharge may be made to bring out artificial striæ from an amorphous discharge, the position of the striæ depending upon the character of the air-spark used. The positions occupied by striæ in the one case will be occupied by dark spaces in the other, and *vice versâ*.

The facts here adduced, together with many others based upon a long series of experiments, all tend to the conclusion that, whatever the number or form of the striæ in a stratified column, each stria is to be regarded as a physical unit, and that in each unit we have represented all the elements of a complete discharge. The form of each stria is in every case determined by that of its immediate predecessor, reckoned from the negative end. This may be verified, among other ways, by observing the form of the successive striæ when distorted by the influence of a magnetic field. The same research has further established the fact that the negative glow and the haze behind it, which terminates in what is usually known as the negative dark space, is a stria turned as it were inside out by the influence, the shape, and the character of the negative terminal. From the mode in which this stria is connected with the negative terminal it has been called the "anchored stria."

The relief effects, may, however, be produced equally well by connecting a point on the surface of the tube with the opposite, or non-air-spark terminal, instead of with earth. By this means we supply a charge of electricity of the opposite name to that with which the tube has been charged, and obtain a result of a similar character to that of ordinary relief.

Alongside of the relief effects above mentioned there is also a system of what we have termed "special effects," which latter are converse to the former, each to each. These are produced by connecting a point on the outside of the tube with the air-spark terminal itself. The special effect with a positive air-spark is equivalent to a relief effect with a negative air-spark, and *vice versâ*.

Lastly, all these effects may be produced by means of impulsive discharges to the outside of the tube from an independent source of electricity, such as a second Holtz machine. And, *mutatis mutandis*, the corresponding effects may be produced by this method even on a non-sensitive discharge. This completes the entire cycle of phenomena due to impulsive action *ab extra*.

The character of these effects being known once for all, this impulsive action may be used as a test of the nature of a discharge (*i.e.* whether positive or negative) passing through a given tube. For example, we may experimentally verify in the case of a coil discharge what might have been anticipated on the principles now established. Such a discharge is in fact equally intermittent from both ends. There is no reason why either terminal should be regarded as the air-spark terminal rather than the other. Hence we might expect that the discharge would be positive through about one-half of the tube, and negative through the remainder, with a neutral zone between them. And such proves to be the case. But more than this, if we attach a small condenser to either terminal of the tube, so as to tone down the impulsiveness of the discharge at that end, we can thereby alter the proportions of the positive and the negative parts of the discharge and shift the position of the neutral zone at will.

The distinctive character which it is thus possible to convey to the whole, or to the two parts of one and the same discharge, naturally leads us to examine whether it be not possible entirely to separate one from the other, and to produce what may be called a unipolar discharge. And this in fact may be done; by connecting the one terminal of the tube through an air-spark to one branch of the circuit, and by leaving the other disconnected, we may produce a discharge which, having plunged blindly into the tube, and finding no response from the other end, returns upon itself, and finds exit by the way by which it came. The unipolar discharge is essentially intermittent, and therefore sensitive; the positive is conical in form and tapering towards its end; the negative is broad, and, so far as it extends, it fills the entire width of the tube. Lastly, two unipolar discharges of the same name can be produced in the same tube; they repel one another, and each returns like a single one.

From these experiments we conclude that the independence of the discharge from each terminal is so complete that we can at will cause discharges from the two terminals to be equal in intensity but opposite in sign (as in the case of the coil), or of any degree of inequality (as in the case of the coil with a small condenser). Or we can cause the discharge to be from one terminal only, the other terminal acting merely receptively (as in the case of the air-spark discharge); or we can cause the discharge to pass from one terminal only and return to it, the other terminal not taking any part in the discharge; or, finally, we can make the two terminals pour forth independent discharges of the same name, each of which passes back through the terminal whence it came.

One of the most important consequences which follows from these considerations is that the discharges at the two terminals of the tube are so far independent as to be primarily determined each by the conditions at its own terminal, and only in a secondary degree, if at all, by the conditions that exist at the opposite terminal. And since the discharges are not necessarily the same at both terminals, the tube must contain free charges at different times. A tube is therefore not like a conductor, but is an independent electrical system, holding much the same position as the air-vessel in a forcing-pump. All the electricity that goes into it goes out again, but this is true only when we consider the whole discharge from the beginning to the end, and it may not be true even approximately during a small finite time. This independence of the discharges from the two terminals in the passage of electricity through rarefied gases dissipates the error of seeking analogies in metallic conduction; and shows that any obedience to regular laws as to change of potential as we proceed along the tube, resistance, &c., must arise from the fact that the effects measured are really average effects over an interval of time very long compared with the duration of the individual discharges.

The importance which attaches to the negative end of the discharge has led experimenters to examine whether the features appertaining to it could not be still further enlarged. And the only thing requisite to carry the experiments to a limit was an instrumental method of improving the vacuum to the degree required. This was furnished by Mr. Crookes' refinements on the Sprengel pump. In a series of most remarkable experiments he has shown, as mentioned above, not only that the striated column may be reduced to zero, but that the anchored stria itself may be so driven back that the blank space in question may be made to occupy the entire length of the tube.

When an exhaustion such as that described, or an exhaustion nearly equal to it, has been reached, a phenomenon, previously noticed, but not before made the subject of serious inquiry, presents itself. Certain parts of the interior surface of the tube become luminous with phosphorescent light. The colour of this light depends on the nature of the glass, and not in any way on the nature of the residual gas within the tube, nor on the substance of which the terminal is made. With German glass the phosphorescent light is green, with English glass it is blue. But the portion of the glass thus rendered luminous depends upon the form and position of the negative terminal. This phenomenon is supposed to be due to the streams of gaseous particles shot off from the neighbourhood of the negative terminal during the discharge. Although there is reason to think that these streams are an accompaniment rather than an integral part of the discharge, yet the particles would seem to be themselves charged with electricity, inasmuch as their paths are affected by a magnet, just as is a movable conductor carrying a current, or a charged body in rapid motion.

The whole subject of these streams, their power of heating metals and other substances, the shadows cast by bodies interposed in their path, and other properties of them, have been so well and so fully illustrated by Mr. Crookes both in published memoirs and in a lecture before this Association, that it is unnecessary for me now to dwell upon the subject in detail.

Their nature and properties, however, having been thus in the main determined, these streams have proved a valuable auxiliary in an investigation of what have been called the "small time-quantities" involved in the discharge. The discharge is, as has been already shown, a complex phenomenon, the various parts of which, although not entirely separable, may be shown to occupy different periods of time; and the length of these periods may be compared with one another, and with other known electrical phenomena. We cannot, it is true, make any absolute determinations of the time occupied in any of them, but we may still form a table of relative magnitudes of these small time-quantities. And I will now endeavour in a few words to give some idea of the nature of these quantities, and of the method whereby they have been measured.

If we take a tube of such high exhaustion as to cause the discharge to become intermittent, or if we use a positive air-spark of sufficient length with a tube of fair exhaustion, phosphorescent light, due to molecular streams, will be seen on the inner surface of the glass near the negative terminal. If then a patch of tinfoil, connected with earth, be placed on any other part of the tube, it will cause negative relief discharges to take place from the glass immediately within it, producing phosphorescence on the opposite side of the tube.

If any solid object, such as a piece of wire, should be present in the tube below the point of contact, it will cast a shadow on the phosphorescence, precisely as in Crookes' experiments with the streams from the negative terminal. If there be two points of relief contact, the same object will throw two shadows, in directions conformable with radiations from each. To these, other experiments might be added.

A determination of the precise directions in which these molecular streams issue from a relieving surface is not a very simple problem; and we must here content ourselves with showing that, in the case of intermittent discharges at least, the streams do not issue normally. If a strip of tinfoil placed along the tube be used as a relieving surface, the phosphorescence takes the form of a sheet wrapped round the tube; if the strip be wrapped round the tube, the phosphorescence takes the form of a sheet laid along the tube. If contact be made with the finger over a finite surface, or by a ring of wire laid close upon the tube, the phosphorescence takes the form, approximately, of the evolute of an ellipse. In all these cases the illumination is somewhat irregular; but the geometrical elements of which the phosphorescent figure is composed, and the stripes or striations of more intense light, are always formed at right angles to the longer dimension of the contact piece. This being so, suppose that we place on the tube a strip in such a curve that the normal planes to the curve will pass through the tangent at the corresponding point of the image of the curve, *i.e.* the curve on the opposite side of the tube, each point of which is exactly opposite to a point on the tinfoil. In such a case all the striations will lie along the curve formed by the locus of the central patches of phosphorescence, and the result will be a single bright curved line of phosphorescence without any spreading out or striated margin. The curve fulfilling these conditions will be a helix, whose pitch is half a right angle. Experiment confirms the anticipation.

One more step in the study of these molecular streams is necessary for our present purpose, namely, an application to them of the same method which we have used with the electrical discharges themselves; viz. we must examine the effect of an inductive stream produced *ab extra* upon a direct stream due to the discharge inside the tube. These effects may be described generally as the interference of molecular streams.

If the finger be placed upon a highly exhausted tube through which a discharge with a positive air-spark is passing, the phosphorescence due to the molecular streams from the negative terminal is seen to fade away from the place where the finger rests, and from a region lying thence in the direction of the positive terminal. The effect is that of a shadow over that part of the tube; and as this is produced not by any real intervening object, but by an action from outside, we have termed it a "virtual shadow." The phenomenon is due to a beating down of the streams of molecules coming from the negative terminal, by the transverse streams from the side of the tube immediately within the part touched.

The interference of two molecular streams may be further illustrated by a variety of experiments, and in particular by arranging within the tube a conductor of some recognisable form—say skeleton tetrahedron. If the tube be touched at a place opposite to this object a shadow of the latter will be formed in the relief phosphorescence; but if the tube be touched also at a point on which the conductor rests, the shadow will be splayed out in a striking manner. This splaying or bulging of the shadow is due to the interference of the molecular streams issuing from the surface of the conductor, which then acts as a *quasi* negative terminal, with the original relief streams issuing from the first point of contact.

With the help of these properties we are able, by connecting a patch of tinfoil on the tube with earth, or with the negative terminal itself, or with a second patch elsewhere on the tube, to detect the presence or absence of a demand for negative electricity; to localise the main seat of such demand; and even to compare the electrical condition of different parts of the tube at the same time or of the same parts at different times during the very passage of the discharge. In this way we approach the question of the small time-quantities involved in the discharge.

And, in the first place, it must be understood that the whole duration of one of these intermittent discharges is comprised within a period of which the most rapidly revolving mirror has been incompetent to give any account. It may be in the recollection of a few of my audience that when the discharge from my great induction-coil was exhibited at the Royal Institution with tubes on a revolving disk the discharge showed a durational character as long as the coil alone was used; but as soon as a Leyden jar was introduced, which was in the main equivalent to an air-spark in a continuous current, the durational character disappeared, and nothing was visible but a bright line, the width of which depended, not upon the duration of the discharge, for no velocity of rotation in any way affected it, but only on the width of the slit through which the discharge in the tube was seen. But, notwithstanding the extreme rapidity with which the discharge is effected, our experiments have already shown that the spark or discharge is a complicated phenomenon, the various parts of which take place in a certain order or sequence of time; and that in virtue of this sequence we have succeeded, at the various pressures comprised within our range, in affecting and modifying it *in transitu*. This suggested the idea that, although the subject is surrounded with difficulties, it might still be possible to form some relative estimate, at all events, of the time occupied by the various parts of which the whole phenomenon is composed. And in fulfilment of this the following are some of the conclusions to which we have been led.

The time occupied in the passage of electricity of either name along the tube is greater than that occupied in its passage along an equal length of wire.

This may be shown by connecting metallically a piece of tinfoil near the air-spark terminal with another near the distant terminal; for it is then seen that the former derives as much relief from the latter as if the latter were not on the tube. This shows (1) that at the time when the electric disturbance reached the nearer piece of tinfoil the more distant piece was unaffected, and (2) that the disturbance propagated along the wire reached the second piece before the arrival of the same disturbance propagated within the tube.

The negative discharge occupies a period greater than that required by the particles composing the molecular streams to traverse the length of the tube, but comparable with it.

Proofs of this proposition are to be found in the phenomena of virtual shadows, and in other instances of the interference of molecular streams; but, omitting detailed experiments, the general argument on which the above conclusion is based is as follows: If two molecular streams, one issuing with positive relief from the side of the tube, the other coming from the negative terminal, show signs of interference, it is clear that the former of these, which certainly started first, must have continued to flow, at all events, until the arrival of the latter.

The time occupied by the passage of electricity of either name along the tube is incomparably shorter than that occupied by the emission of the molecular streams, or (what is the same thing) the time occupied by the negative discharge.

In support of this conclusion we have time only to mention a single experiment. If two pieces of tinfoil connected by a wire be placed, one near the negative, the other near the positive end of a tube through which a negative discharge with a rather long air-spark is passing, the former will show relief (positive) effects, the latter special (negative) effects; but no phosphorescence will be caused at the latter, however long the air-spark used. When the second patch is lifted off the tube and placed upon another through which no current is passing, phosphorescence is immediately produced. The explanation of this appears to be as follows: The negative electricity, bursting into the tube, summons all the positive which it can draw from the tinfoil. This is answered so promptly, that the second patch gives up to the first through the medium of the wire all the positive that it can yield, or, which is the same thing, draws off from the first all the negative that it can obtain; and this is done before the advancing negative reaches the distant patch. But so rapidly does the negative advance, that it reaches the distant patch before the molecular streams have had time to flow from the latter in a sufficient stream to produce phosphorescence; and it reaches it in time to revoke the supply of positive to the nearer, and to draw back the supply of negative which would have come to, and with it the molecular streams which would otherwise have flowed from, the further patch. When the second patch is placed on an independent tube, where no such revocation is possible, phosphorescence actually appears, showing that the revocation is no mere supposition, but a real phenomenon.

From the last two laws it follows as a consequence that negative electricity, and therefore also electricity of either name, in the tube outruns the molecular streams.

We may now fairly ask whether the phenomena which we have been studying have any counterpart in the larger operations of nature which are going on around us, and whether the conclusions to which we have been led afford any explanation of observed facts? Many natural phenomena doubtless fundamentally depend upon electricity; how many we hardly yet know. But there are two in particular, namely, lightning and the aurora, which are unquestionably electrical, and whose correspondence with the spark proper, and with the discharge in rarefied gases, respectively has often been noticed. On these I venture to offer a few remarks.

To say that both of these phenomena are dependent on the electrical state of the atmosphere is not saying much; both for other reasons, and especially because we do not know upon what atmospheric electricity itself depends. But it is clear that it is to a knowledge of the distribution of such electricity that we must look for a proximate, as well as an approximate, explanation of the facts.

In a thunder-cloud we have an aggregation of aqueous particles small enough to remain, temporarily at least, suspended in the air. All of these, it would appear, are similarly electrified, and by their mutual repulsion are restrained from further coalescence. By their presence the ground below the cloud becomes inductively electrified in the opposite sense; and as soon as the cloud by its motion comes within sparking distance, or by an increase of its charge attains sufficient tension, a spark discharge takes place, which, as we have seen above, is a flash of lightning. A similar action may naturally take place between two clouds oppositely electrified. The electrical tension required for a flash of lightning is of course enormous. It has been calculated that in order to produce directly from a battery of the most favourable construction a spark of 42 inches, equal to that given from my great induction-coil, from 60,000 to 100,000 cells would be necessary; while for a flash of lightning a mile long not less than 3,500,000 cells would be required.

In some interesting experiments on water flowing from a small orifice in a cistern Lord Rayleigh has found that the breaking of the continuous column into drops is checked by communicating to it a small charge of electricity; but that it is promoted by a large charge. We may imagine with him that something of the same kind takes place in the cloud; and that before the flash the aqueous particles are kept apart by mutual repulsion due to their being all highly charged with electricity of the same name; but that after the flash they are left either without charge or with so slight a charge as to promote their coalescence and their consequent fall in the form of rain. This would be an explanation of the well-known downpour which frequently occurs after a flash of lightning.

There is moreover another form of lightning to which the discharge in our vacuum-tubes offers, to say no more of it, considerable analogy, namely, that commonly known as ball lightning. The appearance of ball lightning is described as that of a luminosity or ball of fire moving generally towards the earth, in a direction more or less oblique, and disappearing in most cases before reaching the ground. In some tubes, the exhaustion of which is very moderate, say, having a pressure of several millimetres of mercury, it happens not only that the blocks of light termed entities by Mr. De La Rue are formed, but also that these entities travel along the tube from the immediate neighbourhood of the positive terminal to a finite distance in the direction of the negative, and then disappear. It would seem not unreasonable to suppose that ball lightning is due to conditions not dissimilar to those of such tubes, namely, to a discharge occurring in the upper regions of the air, at an elevation of perhaps twenty miles, more or less, where the pressure is moderate, that is to say, greater than that under which an auroral-like display could take place, and yet less than that which would give rise to a true spark or ordinary flash of lightning. And if further we effect the discharge in the tube by the gradual outpouring of electricity from a charged Leyden battery, or other condenser, through a suitable resistance, or if we use an induction-coil, then the condenser, or coil, will represent the charged cloud, or portion of the atmosphere, from which the phenomenon proceeds; and the analogy will perhaps be considered sufficiently close to render further observations in proof or disproof of the theory desirable.

Let us now turn to the aurora. Sufficient experiments have been made this evening to show that the discharge in rarefied gases differs from that in gases at higher pressures; and that the difference corresponds exactly to that observed between the diffused, gentle, and flickering play of the aurora and the sudden crashing spark of a flash of lightning. It is also abundantly clear that at an elevation of twenty or thirty miles above the earth's surface the atmospheric rarefaction must be such as to convert what would be lightning at a lower level into a discharge similar in the main to that in a vacuum tube.

Further, it is an ascertained fact that a difference of electrical condition in different portions of the atmosphere often prevails. We have, therefore, not unfrequently present in regions at moderate elevations, say from twenty to fifty miles, all the conditions necessary for the production of an auroral display.

And not only so, but our experiments enable us to determine, at all events approximately, some limits of elevation within which this phenomenon can occur, and thereby to check the very divergent estimates of those who have observed it. Estimates of the altitude at which the auroral discharge takes place have been made from simultaneous observations at different points, and these have ranged up to fifty or sixty, and even to 281 miles. But even the lowest of these appears to be improbable. The pressure at which the resistance of air is least is a little less than ·4 of a millimetre of mercury; and the corresponding elevation is about thirty-eight miles. A vacuum tube measured by hundred-thousandths of an atmosphere would correspond to an elevation of a little more than eighty-one miles. Through a hydrogen vacuum at this pressure Mr. De La Rue failed to obtain a discharge with 11,000 cells; and he adds that "it may be assumed that at this height the discharge would be considerably less brilliant than at thirty-eight miles, should such occur."

It seems to be a well-ascertained fact that in high latitudes there are fewer thunderstorms and more auroras than in lower latitudes. This fact points to the conclusion that, after a disturbance, the re-distribution of atmospheric electricity is effected by one process or by the other, according to, or rather in consequence of, the meteorological differences between arctic, temperate, and tropical regions. In colder regions, where the air is generally drier, and, consequently, a better insulator than in warmer, there is less liability to a discharge taking place in the lower and denser strata; that is, there is less liability to lightning. But at higher levels the rarefaction may compensate this, and cause an auroral discharge to take place instead.

There are other features in which a comparison may be made between the auroral light and vacuum discharges. These discharges, when free to arrange themselves in a magnetic field, follow the lines of force; the auroral streamers appear to run parallel to the dipping needle. The colour of such discharges varies with the exhaustion; that of the aurora varies, like that of an air-vacuum, from red almost to white; and in the absence of independent observations to the contrary, we may fairly attribute the variety of tint in the aurora partly to a diversity of elevation, and, consequently, of rarefaction in the region where it takes place, but partly also perhaps to the electrical conditions present anterior to the passage of the discharge.

These and other features of the phenomenon of the aurora, as well as the kindred subjects of earth currents, the disturbances of the magnetic needle, and the connection of the whole with solar radiation as a predisposing cause, have been brought together under one theoretic view by Prof. Stokes, to whom I am indebted for much of what I have here said on the subject.

Having thus gone through, so far as circumstances permitted, the experimental and inductive parts of my subject, it might have been very pleasant to have cast aside for a few moments the links which connect strict induction with what may be termed the fixed points of ascertained fact; and, restrained only by the more elastic bonds of scientific imagination, to have indulged in speculations about things still lying on the borders of science and of dreamland. But I must leave each of you to follow out this vein of thought after your own fashion; and, confining myself to a single remark, I will simply indicate the direction in which my own thoughts on the present subject are inclined to turn. The remark is this: If in the search for a solution of the mystery of electricity there be one element more deserving our attention rather than another, it is that of time. We have utilised this element in our experiments with the revolving mirror; and we have touched upon its more subtle influences in our conclusions about the small time quantities in relation to the discharge.

All operations of nature take place in time. It is in the time-sequence of phases, often apparently simultaneous, but in reality successive, that we may hope to strike the origin of many complicated phenomena. Time is the ocean beneath whose waves and whose currents the secret fountains of truth are to be sought. Time is the ocean whose mighty stream encircles our life. Time is the ocean whose "countless smiles" gave birth to Venus and the Nereids and all the infinite forms of beauty and of brightness which play around our youth. Time is the ocean from whence sprang also the steeds of Neptune, typical of the strength of our more mature years. Time is the ocean in whose loving arms we fall asleep, when the sun sinks low on the horizon, and the shades of night are creeping over the heavens, and all things tell us that our course is run.

BIOLOGY AS AN ACADEMICAL STUDY[1]

II.

IT may help to the understanding of what I mean by a sound method of biological teaching if I give a brief outline of the course of study I hope to pursue with my students this session. It is hardly necessary for me to state that this course is derived from Prof. Huxley's by a natural process of descent with modification.

In the first place there will be some four or five lectures on a common flowering plant, giving an account of its ordinary structure as seen by the naked eye, of its microscopic structure, of its physiology, and of the process of its development. After each lecture the students will examine for themselves the plant described, learning not only to dissect it in the ordinary way, but to make preparations for the microscope. By this means they will be familiarised with the use of the microscope, the employment of staining fluids, and other reagents used in the investigation of minute structure, and with the chief processes of manipulation. As the laboratory will be open for nine hours a week, so as to give three hours for working out what has been described in each hour's lecture, it is to be expected that a student of average intelligence will, by the time this part of the course is over, have a very fair notion of what a flowering plant is, of the processes by which its life is carried on, and of the manner in which it originates.

The next few lectures, and the corresponding portion of the practical course, will be occupied with a similar treatment of an animal: the one selected, as on the whole the most convenient and the most instructive, being the common sea crayfish of our markets. In the examination of this organism, the students will learn something of the art of dissection, and will further apply the knowledge of microscopic structure which the study of the plant has given them, to the far more difficult problems of animal histology. The study of the crayfish, and the comparison of it, point by point, with the plant, should give a clear conception of the main points of difference and of likeness between the more highly organised animals and plants—between animals and plants as they are generally known to us.

In dealing with these types in the lectures it will be my aim always to proceed from the known to the unknown; to begin with points which every one who has seen a flowering plant or a crayfish must have noticed, gradually leading up to such points of structure as require minute observation to verify them, and above all never to give a definition or a general statement without first supplying the facts from which it is legitimately deducible.

Next, I propose to take a number of types selected on the one hand from the lowest plants, on the other from the lowest animals: to show how these unicellular organisms agree in structure and in the nature of their physiological processes with the individual cells of which the bodies of the higher plants and animals are made up, and to point out how, in dealing with these lowest members of the two kingdoms of organic nature, the boundary line between the two kingdoms tends to disappear, and it becomes very difficult, sometimes even impossible, to say what is a plant and what an animal. The study of these lowly forms will also lead to the question of the origin of life, and it will be necessary to say something of the attempts which have been made to establish the doctrine of spontaneous generation, and to discuss their value.

The consideration of a few other animal and vegetable types, especially such as, although multicellular, exhibit none of the complex tissues found in the higher animals and plants, will bring the introductory part of the course to a close—the part which deals with the general facts and principles of biology. In it the student should learn how animals and plants agree with and differ from each other, and from inorganic bodies; what are the relations of animals and plants to one another, and to

[1] Inaugural Lecture delivered in the University Library, May 2, 1881, by T. Jeffery Parker, B.Sc., Lond., Professor of Biology in the University of Otago. Continued from p. 546.

inorganic nature; what is meant by differentiation of structure, and by the division of physiological labour exhibited by the higher organisms in contradistinction to the lower. He will also have gained some conception of the all-important truth that the higher organisms begin life as a simple cell, comparable to an entire unicellular organism, and that, of that cell, the animal or plant itself, as well as every element of its fully-formed tissues, is a lineal descendant. And these matters will be impressed upon his mind by actual verification of all the more important points; so that he will, it is hoped, have begun to learn the first duty of the student of science—to take things on trust only so long as he is unable to bring them to the test of observation and experiment.

The whole of this part of the course is a modification, adapted to local requirements, of Prof. Huxley's well-known "General Biology" course. It will be seen at once that it serves as an introduction both to botany and zoology, forming a starting-point from which lectures on both these subjects may diverge. I hope to give a few lectures on structural botany on Monday evenings, but the remainder of the ordinary biology course will be purely zoological, dealing chiefly with animal morphology, or comparative anatomy, as opposed to systematic zoology. It is gradually being acknowleged by those most competent to form an opinion, that zoology in this latter sense is a subject of no educational value whatever—I mean as far as the beginner is concerned—since it necessarily follows a course exactly the opposite of that which the scientific novice should pursue. It begins with generalisations, and ends with details; it provides elaborate systems of classification without giving even an elementary knowledge of the totality of organisation of a single animal, and—what is most mischievous for the beginner—it regularly ignores facts not of "classificatory importance," and so tends to offer a premium on superficiality.

The principal groups of animals will therefore be treated partly by the description of "types," selected as exhibiting the chief characteristics of the group, partly by the comparative method—that is, by taking up a particular organ or set of organs and tracing the modifications it presents through a series of groups. The more important fossil members of any division will be considered along with the recent forms, a good deal will be said of the embryology or development of the chief types, and the main facts of their distribution in space and time will be considered, as well as the question of classification and the principles upon which it is conducted.

From time to time the necessity will arise of discussing the relations between these several divisions of the subject and the explanations of them. It will be shown, for instance, that a proximate explanation of the extraordinary changes undergone by an animal in its development from the egg is afforded by the theory that the evolution of the individual is a recapitulation—much abbreviated and distorted—of the evolution of the species. Or, to take another example, it will be pointed out that in the doctrine of evolution we have the only satisfactory explanation of the fact that in tracing back the history in past time of many groups, the boundaries between them tend to disappear, and species are found at last assignable to no existing group, but combining in themselves the character of two or more. As a striking example I may mention the recent discovery of the second known specimen of the fossil called *Archæopteryx*, hitherto supposed to be a true bird, although exhibiting certain approximations towards reptiles. It is now known that Archæopteryx is completely intermediate between reptiles and birds—that it is indeed a feathered reptile; and it cannot be doubted that we have here clearly indicated the line of descent of the group of birds, at the present day so sharply separated from all other vertebrate animals. In the same way the mammalia, when traced back to the earlier tertiaries, are found to be represented by animals which are neither marsupials nor rodents, carnivores nor herbivores, but form a common group of generalised forms, from which the well-marked orders of mammals as we know them to-day are seen gradually to diverge as we trace the fossils from the lower to the upper tertiaries.

While this the greater part of the course is going on, the laboratory work will consist in the dissection of one or more common animals selected as types of each of the chief groups. The Mollusca, for instance, will be illustrated by the cockle or mussel, the slug, and perhaps the octopus; the great group of articulated animals by the crab, sandhopper, beetle, moth, spider, millepede, &c.; the Vertebrata by some common fish, such as the red cod, by a frog if it can be had, by a pigeon and a rabbit. In this way the student will become familiar with the entire organisation of a sufficient number of animal types to enable him to understand the description of other types given him in lectures or in books. Further illustrations of many points of importance will be afforded him by the examination of specimens from the museum, notably in the case of fossils, and in that of the skeleton, which latter, apart from its purely scientific importance, affords an excellent training for the faculties of observation, of comparison, and of memory. Moreover, if the time holds out I hope to be able to let the students see for themselves some of the chief stages in the development of the common fowl—the most convenient starting-point for the study of embryology.

Lastly, from time to time short practical examinations will be held. Subjects will be provided differing from those already seen, and the student will be encouraged to investigate their structure without help, and to compare the results thus obtained with those of the more formal work.

I think no one will doubt that a course of this sort must furnish a true discipline. Whether as a discipline it is superior, *cæteris paribus*, to a classical course—to a study of the grammar and construction of the Latin and Greek languages, and a certain acquaintance with their literature, I must leave to the decision of those who know more of the latter subjects than myself. Certainly a consideration of the faculties the two studies are likely to bring into play, train, and develop, leads one, in the absence of other data, save the sad memories of one's own school work, to assign a distinctly higher value to scientific than to grammatical study as a mental training. But this point has been so often insisted on by men whose words carry weight that no remarks of mine are needed. What I consider it my business to point out is the way in which a course in my own branch of natural science should, and the way in which it should not, be carried on, and I feel convinced that even those who have no knowledge of the subject will see that the training afforded by the course of which I have given a brief outline in observation, in induction and deduction, in the comparative method, and in the true understanding of the relations between cause and effect, is not easily surpassed, to say nothing of the less important, though by no means to be despised, training of the memory, and of the exercise of the imagination provided by theories of molecular structure, and their application to morphological and physiological problems.

As to the effect of these studies upon still higher faculties, I feel that I cannot do better than quote a well-known passage from a lecture of Prof. Huxley's, delivered nearly twenty-seven years ago. He says:—"There is yet another way in which natural history may, I am convinced, take a profound hold upon practical life, and that is by its influence on the finer feelings as the greatest of all sources of that pleasure which is derivable from beauty. I do not pretend that natural history knowledge, as such, can increase our sense of the beautiful in natural objects. I do not suppose that the dead soul of Peter Bell, of whom the great poet of Nature says—

> "'A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more,'—

would have been a whit removed from its apathy by the information that the primrose is a dicotyledonous exogen, with a monopetalous corolla and central placentation. But I advocate natural history knowledge from this point of view because it would lead us to *seek* the beauties of natural objects instead of trusting to chance to force them on our attention."

Indeed the elevating effect of science from this point of view is of quite the same nature as that of art, and with the alteration of a word or two the sentence put by Browning into the mouth of Fra Lippo Lippi expresses exactly the same idea as the passage I have just quoted:—

> "For don't you mark?—We're made so that we love,
> First when we see them painted, things we have passed
> Perhaps a hundred times, nor cared to see;
> And so they are better painted—better to us,
> Which is the same thing. Art was given for that."

One may even go a step further and say, with the Laureate, that he who could know all about one single little flower would know "what God and man is."

I would draw attention to the fact that I have said nothing as to what is often called the practical bearing of scientific instruction. And this purposely; for we who have the charge of higher education in the ordinary sense—as distinguished from professional or technical education—have nothing whatever to do with so-called practical ends. Our business is, as far as in us lies, to train the minds of our students—to teach them to think and to learn for themselves, knowing that whatever career they may choose, this sort of training will be of primary importance to them—will form indeed the surest foundation for any course of professional training they may afterwards choose to follow.

So far I have been considering only the elementary teaching of biology, devoting special attention to the course I propose to adopt for preparing beginners for the Pass Degree, and with certain additions to the work, for Senior Scholarships. It still remains to say something about the course of study for Honours in the biological sciences.

It is enacted in the regulations of the New Zealand University by what seems to me one of the wisest rules in the calendar,[1] that a candidate for honours in biology must specialise—that is, must choose some special branch of either zoology or botany, and work up that branch as fully as his time and opportunity will allow. He has already, in taking his B.A. degree, proved his general acquaintance with zoology or botany; he now has to show that, of some limited department of one of these sciences, he possesses more than a mere text-book knowledge.

Suppose, for instance, that a student selects the group of fishes as his special subject. It will be my duty to direct him to the more important works on ichthyology in the University and Museum libraries, so that while taking the most recent work on the general subject as his text-book, he may, when desirable, refer to the original sources of information and acquire the habit —most essential for a student of science—of seizing upon the points of real importance in a monograph or *brochure*. While undergoing this course of reading the candidate will dissect as many as possible of the more important New Zealand fishes, making careful notes and drawings of their anatomy, and comparing his results with the statements he finds in books.

But it is further enacted that the candidate for Honours shall send in the results of some original research. In the hypothetical case I have chosen the subject for investigation would most probably be an inquiry into some branch of fish anatomy as far as it could be worked out on New Zealand species—the nervous system, for instance, or the skull, or the digestive organs in one of the groups, or the detailed anatomy of some single species.

It is, I think, from this part of the Honours work that the conscientious student will derive the greatest benefit, and it is in the fostering of research on the part of its members that a university performs its highest duty. Until it assumes that position indeed, it is only a step above the high school, differing from it in degree only, and not in kind. It is only when original work is directly encouraged, and indeed looked upon as the goal of university life rather than the taking of a degree or the gaining of a scholarship—in other words it is only when knowledge is not only communicated, but advanced, that a university takes its true place, not as a mere finishing school, but as a centre of sound learning.

In the case of the advanced student I repeat it is only when his work becomes in some slight degree *original* that he derives the greatest possible benefit from it. "Every man," says Carlyle, "is not only a learner but a doer: he learns with the mind given him what has been; but with the same mind he discovers further; he invents and devises somewhat of his own. Absolutely without originality there is no man." It is impossible to estimate the benefit to a man's whole nature of setting him to puzzle out something that has never been thoroughly worked out before, of putting him upon his mettle to spare no effort in the elucidation of the problem before him, and to "hold it crime to let a truth slip." If a man has anything in him this assuredly will bring it out, more than years of absorbing other men's thoughts and verifying other men's results. The problem he has set himself may seem to others quite insignificant, and its solution a matter of no moment—"the pitifullest infinitesimal fraction of a product"—but to him it is all-important—"an ill-favoured thing, sir, *but mine own*."

This brings me to the last point I have to touch upon. It is to be hoped that a certain proportion of the students who study biology here may be brought to look upon it not as a means of education only, but as a pursuit to be carried on after leaving the University. It is interesting to notice how much scientific work in England has been and is done by what may be called scientific amateurs, men who, while engaged in professional or business pursuits, devote their spare time to the advancement of some branch of natural knowledge. And I think I am justified in saying that New Zealand has hitherto been pre-eminent among the Colonies for following out in this respect the traditions of the Mother Country. To say nothing of botany, many groups of animals have already been thoroughly well worked up, and considerable headway has been made with others; but "there remaineth yet very much land to be possessed," and one may venture to hope that workers from this University will before long begin to swell the *Transactions* of the New Zealand Institute and the publications of the Geological Survey. Upon any who may have this laudable ambition before them I would venture to urge the advisability—I might almost say necessity—of acquiring a sound and exact, although necessarily elementary knowledge of biology as a whole, before beginning to study any special branch. The work of a man who knows his own limited branch of science, and nothing beyond, is quite sure to be imperfect, and will most probably be evanescent. The highest results are only to be obtained by studying a group or a species, not only in and for itself, but in connection with other groups or species, by keeping always in mind the possible connection of one's own results with those of others, by remembering that the objects one is studying are not isolated things like coins or postage-stamps, but are *organisms*, whose special characters have been impressed upon them by forces which have been at work from the beginning of all things.

Finally, it is just possible that some day one of our students may be brought to take up biology as a career. I need hardly say that such a one, besides completing his studies elsewhere, would be probably compelled, unless possessed of private means, to exercise his profession either in Europe or in America, since there is very little chance at present of more than one biological appointment in a decade falling vacant in this Colony. But a man with a love for his subject and not afraid of hard work, who, after learning all he could learn here, availed himself of the best teaching at home—at London, Cambridge, or Heidelberg—would, I feel convinced, have every chance of success. He would never get rich; the present practical applications of biology are not such as insure fortunes. He would have all his life to be satisfied with an "*aurea mediocritas*" in matters of finance, but he could count upon what is even better than a large income—increasing joy and constant development through a thoroughly congenial life-work.

[1] I am sorry to see that the Senate at its recent meeting has adopted a regulation which cannot fail to lower immeasurably the standard of the Honours examination in biology. It is proposed in fact to make the candidate take up a special subject in both botany and zoology. A student, for instance, whose predilections are zoological, and who may never have studied botany at all, is to make a special study of "some one family of the vegetable kingdom," as well as of some group of animals. The inevitable result will be that one or both subjects will be crammed, and Honours will cease to have their legitimate value, and will become nothing more than a step beyond the Pass Degree.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The Colleges meet on Saturday, October 15, and the professorial lectures begin the following week. The professors and lecturers in physics have drawn up the following scheme of lectures and classes for the Michaelmas term:—Prof. Clifton lectures on Wednesday and Saturday on terrestrial magnetism, and Prof. Bartholomew Price lectures on Tuesday, Thursday, and Saturday on the dynamics of material systems. Mr. Hayes lectures on electrostatics (treated mathematically). Instruction in practical physics is given daily in the Clarendon Laboratory, under the direction of Prof. Clifton, Mr. Stocker, and Mr. Heaton. Mr. Stocker gives an experimental lecture on elementary mechanics, and Mr. Heaton has a class for problems in elementary mechanics and physics. The above lectures are given in the University Museum. At Queen's College Mr. Elliot gives a course on geometrical and physical objects; at Christ Church Mr. Baynes gives a course on elementary heat and light; and at Balliol Mr. Dixon gives a course on elementary magnetism and electricity.

On Tuesday the Fellows of Wadham College elected Mr. G. E. Thorley to the wardenship of the College, in place of Dr. Griffiths, resigned. It is understood that Dr. Griffiths will continue to reside at Oxford, and will remain a delegate of the University Press and of the Local Examinations.

An examination for Natural Science Scholarships begins on Thursday, October 13, at Exeter and Trinity Colleges. The scholar elected at Exeter will be expected to read for honours in the biological school, and the scholar elected at Trinity will be expected to read for honours in chemistry or physics.

An election to a Brackenbury Natural Science Scholarship at Balliol College will be held in November. Papers will be set in physics, chemistry, and biology. Candidates may offer themselves in two of these subjects, and may also take mathematics or an English essay.

CAMBRIDGE.—Prof. Paget will lecture on Clinical Medicine at the Hospital this term; and Prof. Latham on the Physiological Actions and Therapeutic Uses of Remedies, at Downing College.

Practical Anatomy commenced at the Dissecting Room on October 5; and demonstrations for second year men on October 7. Prof. Humphry's lectures on the Organs of Digestion begin on October 13. A class in anatomy and physiology, preparatory for the second M.B. and the Natural Sciences Tripos, will meet for the first time on October 17.

Prof. Liveing lectures this term on the General Principles of Chemistry, and also on Spectroscopic Analysis, taking limited classes at successive hours on the latter subject; there will be both practical observation with spectroscopes, and explanations of principles and results. Prof. Dewar will lecture three times a week on Physical Chemistry, beginning October 14; and two tutorial lectures weekly will be given in connection with these lectures by Mr. A. Scott, the professor's assistant. Investigations may be carried on in the laboratories, with the approval of the professors. Demonstrations in Volumetric Analysis will be given by one of the demonstrators three times a week.

Mr. F. M. Balfour will give two courses of lectures (elementary and advanced) on Morphology, with practical work, at the New Museums, each course to extend over two terms. Both courses will be on the Invertebrata this term.

Dr. Vines commenced his lectures on the Physiology of Plants at Christ's College on October 12.

Prof. Stuart lectures on Mechanism three times a week; the workshops and drawing office open on October 14. Mechanical drawing and machine designing will be taught in the drawing office; and the use of tools, the elements of practical engineering and the construction of physical instruments in the workshops.

Prof. Lewis has two courses this term, one on Descriptive Crystallography, and the other on the principal minerals known as rock-constituents.

Lord Rayleigh lectures on Electricity and Magnetism; Prof. Cayley on Abel's Theorem and the Theta-functions, the deputy Plumian Professor on Practical Astronomy.

SOCIETIES AND ACADEMIES

LONDON

Entomological Society, September 7.—Mr. H. T. Stainton, F.R.S., president, in the chair.—Rev. A. E. Eaton exhibited a dried specimen of the nymph of a species of *Enthyplocia*, a genus of *Ephemeridæ* previously known only in the adult condition.—Mr. E. A. Fitch exhibited a larva of *Zeuzera æsculi*, infested with a species of *Encyrtus* in extraordinary numbers; specimens of a fly (*Drosophila cellaris*) bred from a bottle of pickles; a series of interesting galls (*Cecidomyidæ*), and some stems of *Equisetum* in which larvæ of *Dolerus eglanteriæ* were feeding.—Mr. T. R. Billups exhibited six new British *Ichneumonidæ*.—Mr. C. O. Waterhouse exhibited a specimen of the common mouse attacked by the larva of an *Œstrus*.—Sir S. S. Saunders exhibited specimens of *Sarcophaga lineata*, Fall., which destroys locusts in the Troad, and of *Chalcis flavipes*, Panz., parasitic on the parasite itself.—The president read a letter from the Colonial Office respecting the report forwarded by the Society on locust parasites.—Mr. C. O. Waterhouse read descriptions of some new *Coleoptera* from Sumatra.—Mr. J. S. Baly communicated descriptions of some new species of *Eumolpidæ*; and Mr. A. G. Butler communicated a list of butterflies collected in Chili by Mr. T. Edmonds.

PARIS

Academy of Sciences, October 3.—M. Wurtz in the chair.—M. Dumas communicated the decisions recently come to by the Congress of Electricians on electrical standards. He also exhibited an ingot of steel produced by Dr. Siemens in the Exhibition, by electric fusion (in fourteen minutes) of a few kilogrammes of steel in a magnesia crucible. The expenditure of fuel to drive the machine was less than that required by direct fusion in a common furnace.—On the secular displacements of the planes of orbits of three planets, by M. Tisserand.—Public experiments on vaccination of symptomatic *charbon*, made at Chaumont (Haute-Marne) on September 26, 1881, by M. Bouley. Symptomatic charbon is proved to be distinct from bacteridian charbon; *inter alia*, the microbe of the former, introduced into the veins, insures future immunity, producing at the time only slight fever. This vaccination of MM. Arlong, Cornevin, and Thomas, differs from that of M. Pasteur in that the natural virus is used in all its energy (not attenuated). Care has to be taken not to let the virus enter cellular tissue, but only the (jugular) vein. The experiments here recorded were made on 25 young cattle, 13 of which had been vaccinated, and the results distinctly vindicate the method. In the second injection the cannula was deeply inserted in muscular tissue.—On a new application of the equation of Lamé, by M. Gyldén.—Observations of the comet *d* 1881 (Encke) and *e* 1881 (Barnard), made at Paris Observatory, by M. Bigourdan.—Application of radiophony to telegraphy; multiple inverse electric teleradiophone, by M. Mercadier. (This was a sealed packet, deposited May 31.) A continuous current traverses a series of radiophonic selenium receivers and telephones at station A, then the line, then another series at B. Before each receiver a wheel with circle of holes rotates regularly, and the passage of the light rays is blocked at will with a Morse key, giving interruptions of the musical notes in the telephones, corresponding to Morse signal. The wheels are arranged to give different notes, and each listener with a telephone concentrates his thought on a particular note. The system may be applied to lines of great length.—On a new electromagnetic pointer designed for experimental researches, by M. Noel. The author sought a means of estimating very quickly and exactly the physiological duration of tendinous reflex phenomena in muscles. A needle is arranged with a friction-coupling of two hollow cones, one of which, when in contact with its concentric cone, causes the needle to traverse a graduated disk at the rate of once in one second; contact of the other cones stops the needle. The motion is determined by currents in a Hughes differential train, *i.e.* two opposite electro-magnets with common armature in equilibrium between. When one current passes through their four coils, the armature is attracted to one magnet, and remains there till an opposite current brings it to the other. These currents flow respectively on applying to the tendon an instrument, which closes the first circuit, and on contraction of the muscle, which opens this circuit and closes the other.—On secondary batteries, by M. Rousse. In one arrangement he uses a palladium plate as negative pole, and lead as positive; the liquid being sulphuric acid solution (one-tenth). Another battery also giving good results is made with sheet-iron, lead, and a solution of sulphate of ammonia (the lead either pure or covered with litharge, or pure oxide or sulphate, or all these mixed). Again, sheet iron, ferro-manganese, and sulphate of ammonia solution.—On a manganese battery, the salts of which are utilised or regenerated, by M. Rousse. Ferro-manganese is substituted for zinc in the Bunsen battery. For weak currents and in apartments, permanganate of potash is used for depolarisation (in other cases nitric acid). The salts produced are sulphate and nitrate of manganese, or sulphate and nitrate of potash. Permanganate of potash, or peroxide of manganese is then obtained by chemical processes.—On levulose, by MM. Jungfleisch and Lefranc.—On an egg of an ancient ostrich, by M. Ballaud. This was from a subterranean columbarium at Gonzaga. He compares its chemical constitution with that of a recent egg. There is more carbonate and phosphate of lime, and less carbonate of magnesia, &c.

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