THURSDAY, JANUARY 15, 1874

THE POLLUTION OF RIVERS

THE Rivers-pollution Commissioners (Prof. Frankland and Mr. J. C. Morton), having, during the last five years, made and published more than 2,000 analyses of river and other waters throughout England, Scotland, and Wales, before and after pollution, and no less than 1,200 examinations of impure drainage waters, and having visited and reported concerning the effluent waters from 245 Chemical-dye and Print-works, Paper-, Cotton-, and Woollen-mills, and mines and works of various kinds spread over the country, have recently published their fifth report on river pollution from mining operations, reserving to themselves in their forthcoming and last report the consideration of the potable waters of Great Britain.

The importance of this systematic and thoroughly scientific examination of the composition of the running water on the surface of our country can hardly be over-estimated, and the value to the nation of the mere analyses of the waters is such as amply to repay the cost of the Commission. In addition, however, to the special value to each district, to corporate bodies, or even to individual manufacturers and riparian proprietors which these analyses of river and drainage waters possess, they are of the highest importance as forming the body of evidence upon which alone action can be taken with regard to legislation on the subject of the prevention or abatement of river pollution throughout the country. That some measure to ensure a greater degree of purity in our rivers, especially those passing through the manufacturing districts, must, before long, be carried out by the Legislature, is admitted not only by those who opposed Mr. Stansfield's proposals of last year, but even by the manufacturers who are now helping to foul the streams. The question which has to be settled is not whether anything is to be done to remedy the certainly disgraceful state of some of our streams, but rather to what extent can the purification be pushed without detriment to the industry of the district; and when this has been decided comes the next question, how this partial purification is to be effected. That it can only be a partial purification is clear from the conclusions of the Commissioners themselves, who do not propose any plan by which the water of our rivers, in populous districts at present little better than sewers, shall be so purified as to be fit for drinking purposes.

Without attempting to give even a part of the data upon which the Commissioners base their conclusions, and declining altogether, as inopportune, to criticise their scheme, it appears to be desirable that conclusions arrived at after so much labour and consideration should be made widely known.

The proposal, then, which the Commissioners make as in their opinion the best and most feasible means of legislating on the prevention of river pollution is the establishment of certain standards, the infringement of which shall render the water liable to be deemed polluting and inadmissible into any stream, provided always that no effluent water shall be deemed polluting if it be not more contaminated with any of the polluting ingredients than the stream or river into which it is discharged.

The standards are as follows :—

(*a*) Any liquid which has not been subjected to perfect rest in subsidence-ponds of sufficient size for a period of at least six hours ; *or* which having been so subjected to subsidence, contains, *in suspension*, more than one part by weight of dry organic matter in 100,000 parts by weight of the liquid, *or* which, not having been so subjected to subsidence, contains, *in suspension*, more than three parts of dry mineral matter, or one part by weight of dry organic matter in 100,000 parts by weight of the liquid.

(*b*) Any liquid containing, *in solution*, more than two parts by weight of organic carbon, or 0·3 part by weight of organic nitrogen in 100,000 parts by weight.

(*c*) Any liquid which shall exhibit by daylight a distinct colour when a stratum of it one inch deep is placed in a white porcelain or earthenware vessel.

(*d*) Any liquid which contains, in solution, in 100,000 parts by weight, more than two parts of any metal except calcium, magnesium, potassium, and sodium.

(*e*) Any liquid which, in 100,000 parts by weight, contains, whether in solution or suspension, in chemical combination or otherwise, more than 0·05 part by weight of metallic arsenic.

(*f*) Any liquid which, after acidification with sulphuric acid, contains, in 100,000 parts by weight, more than one part by weight of free chlorine.

(*g*) Any liquid which contains, in 100,000 parts by weight, more than one part by weight of sulphur, in the condition either of sulphuretted hydrogen or of a soluble sulphuret.

(*h*) Any liquid possessing an acidity greater than that which is produced by adding two parts weight of real muriatic acid to 1,000 parts by weight of distilled water.

(*i*) Any liquid possessing an alkalinity greater than that produced by adding one part by weight of dry caustic soda to 1,000 parts of distilled water.

(*k*) Any liquid exhibiting a film of petroleum or hydrocarbon oil upon its surface, or containing, in suspension, in 100,000 parts, more than 0·05 part of such oil.

The Commissioners further add that any law having for its object the prevention of river pollution, should

1. Absolutely forbid, under adequate penalties, the casting of solid matters into river channels.

2. Enact the foregoing standards of purity below which any liquid discharges into water-courses should, with the exceptions already mentioned (certain few short mining rivers), be forbidden.

3. Give power to all manufacturers in towns, except those of gas, paraffin oil, pyroligneous acid, animal charcoal, tin-plate, and galvanised iron, to discharge their drainage water into the town-sewers under suitable regulations.

4. Confer additional powers on corporations, local boards, manufacturers and mine-owners, to take land compulsorily under "Provisional orders" for the purpose of storing their waste refuse, or of cleansing sewage or other foul liquids either by irrigation, filtration, or otherwise.

They are of opinion that Government Inspectors (similar to the Inspectors under the Alkali Act) should be appointed, to whom should be committed the duty of detecting and proving offences against the law, and of procuring the conviction of offenders. They consider that the formation of River Conservancy Boards for authorising and carrying out river improvements will in course of time become imperative, but they are convinced that the thing of immediate importance in connection with river improvement throughout the country, is simply the prohibition, under adequate penalties, of the gross pollution which at present renders so much of the running water of this country useless to manufacturers, agriculturists, and the like.

The time has not yet arrived for the full discussion of these proposals. We shall doubtless hear much on this subject in the approaching or in the next session in parliament. It is, however, certain, from the opposition made to the bill of last year, that manufacturers do not as a rule agree with the Commissioners as to the feasibility of enforcing the proposed standards of purity, as regards the effluent water from works of various kinds. Nor is public opinion respecting the other and far more important source of pollution, the sewage of towns, in a sufficiently advanced or satisfactory condition to render legislation easy. It is not, for instance, clear how one and the same system, say of irrigation, can be applied to all districts possessing different soils, rainfalls and situations. Indeed, the more we consider the whole question of the prevention of the pollution of rivers, the more difficult does any general method of treatment appear to be. Each locality has its own peculiarities, and a system of prevention which is suited to one district may be inapplicable or inexpedient in another. But even supposing that when the subject comes before Parliament that difficulties are found to be of such a character as to render it impossible to legislate upon the exact basis laid down by the Commissioners, still the value of their conclusions, and of the mass of experimental evidence which they have collected, is extreme: and they have most fully earned the gratitude of all those interested in the satisfactory solution of one of the most important, though most difficult, questions of our social economy.

THE CONSERVATION OF ENERGY

An Elementary Treatise on Energy and its Laws. By Balfour Stewart, M.A., LL.D., F.R.S., Professor of Natural Philosophy at the Owens College, Manchester. (Henry S. King & Co., 1873.)

IT is the proper function of Science to discover, among the ever-changing phenomena of the world, the permanent relations which are the conditions of reasonable thought. When we understand these relations well enough to express them in words we call them "Laws of Nature." When they rise to a higher stage of development and have become invariable habits of thought, we call them "Things."

Thus ice, under certain conditions, ceases to be ice. We observe that when the ice melts water appears in its place, and we find that there is always so much water in place of so much ice. We therefore obtain, in the first instance, a *law* of equivalence between a certain quantity of ice and a certain quantity of water, and finally, we arrive at the conclusion that water and ice are the same *thing* in different forms.

We are thus led to inquire what it is which remains permanent in the midst of all apparent changes, and the result of this inquiry has been the enunciation of a consistent definition of the quantity of matter in a body, and the establishment of the doctrine that the quantity of matter in a body is invariable, whatever transformations it may undergo.

This doctrine of the "Conservation of Matter" lies at the foundation of all reasoning, whether in physics or in chemistry. When the progress of Science rendered it possible to form exact ideas about the motion of bodies, men were again impelled to seek for something permanent, even in motion itself. They endeavoured to form some definition of the "Quantity of Motion" which should enable them to treat this quantity as a *thing* having a continuous existence. The long war between the followers of Newton and those of Leibniz as to whether, in estimating the quantity of motion, the mass must be multiplied into the velocity or into the square of the velocity, was not a mere debate about words and names, for it involved the question whether momentum or *vis viva* were the more fully possessed of that character of permanence which would justify its claim to the title of "The Quantity of Motion."

The doctrine of the Conservation of Energy is the most complete expression hitherto given to the belief that all the changes of phenomena are but different distributions of the same stock of energy, the total quantity of which remains invariable. The characteristic feature of scientific progress during the last thirty years has been the application of principles derived from this doctrine to the various branches of Science. The recent progress of the theory of heat is an instance of the direct and conscious application of the doctrine of the conservation of energy. In his electrical discoveries Faraday also was guided by the same doctrine, though less consciously, as he had no opportunity of becoming acquainted with it in the accurate form in which it may now be stated.

In the volume before us Dr. Balfour Stewart has explained, in a very clear and very elementary manner, what is meant by energy in its two forms, the energy of a moving system, and the energy due to the configuration of the system.

This exposition is so carefully drawn up that we think it ought to be intelligible even to students who approach the subject without any previous training in the technical dynamics of the ordinary text-books. This we consider a matter of great moment for the future progress of Science. It is no doubt easier, in dealing with the present generation of students, to gain their assent to doctrines about energy by deducing them from other principles which have been already taught them as the elementary principles of dynamics. But it is by no means always true in science that those principles which have been longest recognised are really the most elementary. The discovery of principles more fundamental and elementary than those which are already received, is not only of great importance in the philosophy of Science, but it tends to render Science less technical, and therefore more easily diffusible through the mass of society.

Dr. Balfour Stewart, however, has not only endeavoured to give to the ideas of Work and Energy their proper position among the most elementary ideas which we can form, but he has displayed an equal amount of freedom in treating the still more modern ideas of the Dissipation of Energy, and of the difference between exact and statistical knowledge.

Thus his very first words relate to

"*Our Ignorance of Individuals*

"Very often we know little or nothing of individuals, while we yet possess a definite knowledge of the laws which regulate communities.

"The Registrar-General, for example, will tell us that the death-rate in London varies with the temperature in such a manner that a very low temperature is invariably accompanied by a very high death-rate. But if we ask him to select some one individual, and explain to us in what manner his death was caused by the low temperature, he will, most probably, be unable to do so. . . ."

"Nor is our knowledge of individuals greater in the domains of physical science. We know nothing, or next to nothing, of the ultimate structure and properties of matter, whether organic or inorganic.

"No doubt there are certain cases where a large number of particles are linked together so as to act as one individual, and then we can predict its action, as, for instance, in the solar system, where the physical astronomer is able to predict with great exactness the positions of the various planets, or of the moon."

We regret that we have not space enough to quote the whole of this introductory passage, which, in the unpretending language of clear thought, expresses ideas which have as yet been appreciated only by a very small number of scientific men, but which will, in due time, greatly modify the popular notions as to the nature of human knowledge.

The uniformities, therefore, which we observe in our experiments on quantities of matter containing many millions of molecules in continual motion, are uniformities of the same kind as those first explained by Laplace, and in more recent times wondered at by Buckle, and arise from the slumping together of innumerable cases, each of which is by no means uniform with the others.

This statement acquires still greater significance when it is combined with another consideration which Dr. Stewart, if we mistake not, has already insisted on in his opening lecture at the Owens College. This is the distinction between stable and unstable arrangements of matter and motion. A system, whether at rest or in motion, is said to be stable if a slight variation of its initial circumstances will, at the end of a finite time, produce only a slight variation in the configuration or motion at that time. If, on the contrary, a variation, however slight, in the initial circumstances, may produce, in a finite time, a large disturbance, the equilibrium or motion of the system is said to be unstable.

Dr. Stewart illustrates this by several examples, among which we may select a clock as an instance of a stable arrangement in which everything is contrived so that any slight disturbance shall produce as little effect as possible on the position of the hands at any future time. A rifle, on the other hand, is an unstable contrivance, for a very slight pressure on the trigger is sufficient to occasion the motion of the hammer and the explosion of the gunpowder—effects, the energy of which is out of all proportion to the work done on the trigger.

Thus we have stable arrangements which, when at work, are not easily put wrong, and unstable arrangements which are characterised by great delicacy of construction.

The rifle, however, as Dr. Stewart points out, is a machine which, though delicately constructed, is not incalculably so. Its instability is not like that of an egg balanced on its longer axis. But in an animal we find a structure composed of materials which are chemically unstable, so arranged that on account of the changes to which they are liable, the smallest disturbance may produce the most varied states of motion. If, then, an animal is to be compared to a machine, the delicacy of that machine must be incalculable.

It is a metaphysical doctrine, that from the same antecedents follow the same consequents. No one can gainsay this abstract statement. But it is not of much use in a world like ours, in which the same antecedents never again concur, and in which nothing ever happens twice. Indeed, for aught we know, one of the antecedents might be the precise time and place of the event, in which case experience would go for nothing.

The physical axiom which has a somewhat similar aspect is, "That from like antecedents follow like consequents." But here we have passed from sameness to likeness, from absolute accuracy to a more or less rough approximation. The axiom is now applicable only to systems of the kind which we have called stable, in which slight variations in the antecedents produce slight variations in the consequents. In unstable systems, like antecedents do not produce like consequents; and as our knowledge is never more than an approximation to the truth, the calculation of what will take place in such a system is impossible to us.

Dr. Balfour Stewart's discussion of the Dissipation of Energy is perhaps as satisfactory as it could be made in the space allotted to it, and without the use of mathematical methods. Energy is indestructible, but it may cease to be *available*. Here we have a word not familiar in pure science—a word connoting usefulness. We must therefore define what is meant by available, and state the conditions under which we are supposed to be placed

Energy is available when it can be made to do visible work. The conditions under which we attempt to transform energy into work are that we must make use of the interactions of a given system of bodies, moving within a given region of space, out of or into which neither matter nor heat can pass.

If these bodies are in visible motion, we first reduce them to rest by causing them to do a certain amount of work. We thus obtain their energy of visible motion.

If they are now at different temperatures, we convey heat from the hotter to the colder bodies by means of a heat-engine, till the whole system is at the same temperature. We thus obtain a second portion of the available energy.

Finally, if the pressures of different parts of the system are not alike, we allow the portions in which the pressure is great to expand, and so compress the portions in which the pressure is less, the volume of the whole system remaining constant. We thus obtain the third and last portion of the available energy.

The parts of the system are now at rest relatively to each other, and are all at the same temperature and pressure. No more work can be done by the system if it is enclosed within a fixed boundary through which neither matter nor heat can pass. We have exhausted its available energy.

But there are two methods, both of them however unavailable to us, by which the energy of a system, even when rendered in this sense unavailable, may be recovered. One is by allowing the substances to expand into infinite space ; the other is by conveying all the heat through a perfect heat-engine into a refrigerator at the temperature of absolute zero. Hence the importance of excluding these two methods, by limiting the statement to a system enclosed by a boundary through which neither matter nor heat can pass.

Now the doctrine of the dissipation of energy asserts that by the mutual action of the parts of such a system its available energy may be diminished, but can never be increased. If there is difference of temperature, conduction of heat takes place, and this is always accompanied by a diminution of the available energy. If there is visible motion, friction occurs, and this renders a certain amount of the energy unavailable.

Here, then, we have an irreversible process always going on, at a greater or less rate, in the universe. If, therefore, there was ever an instant at which the whole energy of the universe was available energy, that instant must have been the very first instant at which the universe began to exist. If there ever shall come a time at which the whole energy of the universe has become unavailable, the history of the universe will then have reached its close. During the whole intervening period the available energy has been diminishing and the unavailable increasing by a process as irresistible and as irreversible as Time itself. The duration of the universe according the present order of things is therefore essentially finite, both *à parte ante* and *à parte post*.

But, according to pure dynamics, every motion of a system may be performed in the reversed direction subject to the same system of forces. If then at a given instant, every particle of the universe were to have the direction of its motion reversed so as to start anew with an equal but opposite velocity, everything would run backwards from the end to the beginning. We might attempt a description of a world thus recoiling upon itself—the rivers running up into the hills, heat flowing from cold bodies to hot, and men passing over the stage of life from their graves to their cradles, ignorant of the past and remembering only the future, as Shelley sings, in his musical delirium :—

"We have passed Age's icy caves,
And Manhood's dark and tossing waves,
And Youth's smooth ocean, smiling to betray;
Along the glassy gulfs we flee
Of shadow-haunted Infancy,
Through Death and Birth, to a diviner day."

But then we must remember that every characteristic of the past is now transferred to the future, so that if this reversal of nature were actually to occur, we would be quite unconscious of it.

"Thus
Our weakness somehow shapes the shadow, Time."

Now why is this state of things, though dynamically possible, physically absurd ? Simply because it requires the *exact* reversal of the motion of every atom in the universe. If but one atom were to receive a velocity differing infinitesimally from an exact reversal, that atom would leaven the whole universe with that tendency to dissipation of energy which actually exists, and things would go on as they now do.

We must now conclude, by thanking Dr. Balfour Stewart for bringing before the general public in so clear and intelligible a form some of the more intellectual results of physical science. We hope, however, that, in the next edition, the comparison between Euclid's *reductio ad absurdum* and the experimental verification of the results of a physical hypothesis, as given in Art. 118, will be re-written, as it is one of the very few passages which remind us of what is called the popular scientific style.

WEBERBAUER'S "FUNGI OF NORTH GERMANY"

Die Pilze Nord-Deutschland mit besonderer Berücksichtigung Silesiens. Beschrieben von Otto Weberbauer Heft I. mit sechs nach der Natur gezeichneten colorirten Tafeln. (Breslau : Kern ; London : Williams and Norgate.)

THE mycologist has no reason to complain that he has not ample opportunities for identifying the various objects which fall into his hands, if he has but patience and book-learning enough to enable him to avail himself of all the various sources of information. There are not only abundant collections of dried specimens, like those of Rabenhorst, Fückel, and others, on the Continent, with others at home, but every day is bringing forward some new publication of greater or less excellence, with figures illustrative of obscure, or little known species, as well as those which are of more general occurrence. In that most difficult department, the Hymenomycetes, he has a host of excellent figures in Krombholz, more recent copies of which are, unfortunately, by no means equal to the original, while the analyses, for the most part, are unsatisfactory, and sometimes altogether deceptive. Eight numbers have already appeared of the Icones by Fries, which have all the advantage of coming from the author himself of nearly half of the species which are contained in the Epicrisis, a new edition of which is now in the press, including all the more recent additions, and which is proceeding with a rapidity which is somewhat wonderful, since the Prince of Mycologists is at least an octogenarian. It would be easy to mention other important works still in progress both in this country and abroad, but amongst them not the least so is the one whose title is given above, though from its nature the progress must, unfortunately, be somewhat slow. The first part now before us contains figures and analyses of twenty-six species in six plates, with descriptive letterpress, and two parts at least are promised every year.

Great care has evidently been taken in the identification, and it is, we think, a great merit that the author has been content to adopt the commonly received nomenclature, without carelessly sanctioning every new name which has been proposed by ambitious or shortsighted observers. We are glad, moreover, that the measurements are given in French millimetres, and not in parts of German inches, which require reduction.

As the asci vary much in length, only the thickness is given, though, under certain circumstances, as in Sphæriæ, it is often quite as variable as the length. In one or two instances we should have been glad to see more critical remarks, as, for example, under *Peziza venosa*, where the larger figure so exactly accords with that of Fries in the "Atliga och giftiga Svampar" of *Discina perlata*, that we should have been glad to have heard whether there is any real distinction between the two. As we used to find it every spring in our younger days, it was more like the figure of Greville's *Peziza reticulata*, than that before us. Something again might have been said respecting the resemblance of our author's very curious *Peziza corium*, to the North American *Peziza craterium*, with which it has evidently a close affinity. There is, we think, no doubt that the *Verpa digitaliformis* of England is the same with that figured by Herr Weberbauer. We shall be truly glad to find that this beautiful work meets with such success as to ensure its continuance.

It is quite curious to observe how an interest in fungi has rapidly increased in this country. The late Fungus Show at South Kensington was so well attended that the Council offer for next year a very ample list of figures, and as especial prizes are to be given for collections of novelties, or for cultivated species, the meeting will be one of much importance. Even in Scotland, where a short time since fungi were looked on as "abominations," there is a very active movement in their favour, especially amongst the clergy, who have made some very interesting additions to our Mycology, and a fungus-show is projected next autumn at Aberdeen. In England, where some of the older students are passing away, it is a great pleasure to know that the subject is taken up by such strictly scientific observers as Mr. Plowwright, Mr. Renny, and Mr. Phillips, not to mention many other names of great promise.

M. J. BERKELEY

OUR BOOK SHELF

Beeton's Science, Art, and Literature. A Dictionary of Universal Information; comprising a complete Summary of the Moral, Mathematical, Physical, and Natural Sciences; a Plain Description of the Arts; an Interesting Synopsis of Literary Knowledge; with the Pronunciation and Etymology of every leading term. Containing nineteen hundred and eighty Columns, and upwards of six hundred Engravings. 2 vols. (London: Ward, Lock, and Tyler. No date.)

THIS book does not pretend to be, and very evidently is not, more than a compilation from other cyclopædias, and from works on the various subjects of which it treats. So far as we have examined it, most of the information contained in it is derived from the former source, and it is impossible that any thoroughly trustworthy reference-book can be compiled in this manner, especially if the compiler or compilers have no special knowledge of the subjects with which they deal. The work pretends to give only a summary of facts, but in many of the articles much space is wasted by comment and reflection. There is absolutely no article on the Spectroscope, which is referred to *Spectrum*, an article without any illustrative cut, occupying one-third of a column, that might have been written twenty years ago. Why is there no article *Evolution?* and why, under *Development*, is the greater part of the short article occupied with the "Vestiges of Creation," and no reference whatever made to the state of the doctrine in Germany and America? Under the very specific heading *Crannoges* the general subject of Lake-dwellings is discussed, the writer evidently not being aware of the important distinction between the Crannoges of Ireland and the Lake-dwellings of Switzerland. A very poorly-executed copy of Keller's restoration of a Swiss lake-dwelling is the illustration to the article *Crannoges*. We say again no work of this kind can be regarded as a standard reference-book unless the editor has at his command a band of master specialists. The illustrations, as a rule, are inferior, and many of them seem well worn; many, moreover, are totally useless, such as those put beside the article *Drawing* and similar articles, which seem to be inserted simply to make the book take with a certain class. We think there is still room for a comprehensive reference dictionary containing information on all subjects compactly put together, No one at the present day, when there are such multitudes of special treatises in every department of human knowledge, would ever think of resorting to an encyclopædia to *study* a subject; and thousands, we believe, would be thankful for an all-comprehensive reference-book which should present in the briefest possible space the leading and latest facts under each heading free of all comment and speculation. Such a work might be as comprehensive as the "English Cyclopædia," or the "Encyclopædia Britannica," perhaps more so, and yet not exceed in bulk of matter the work at the head of this notice. All the scientific articles in such a work, however, and many others besides, could only be written satisfactorily on such a plan by men of special knowledge in each department; such men alone can judge what is of primary and what is of secondary importance.

Scientific Handicraft; A Descriptive, Illustrated, and Priced Catalogue of Apparatus. Vol. I. Mechanics, Hydrostatics, Hydrodynamics, and Pneumatics. By J. J. Griffin. F.C.S. Pp. 186. (London, 1873).

THIS is a useful Catalogue of Apparatus, which contains an account of the method of using the principal pieces of apparatus which are described. There are also suggestions for keeping instruments in good order. It will be found useful by those who select apparatus for purposes of school teaching or public lecturing; and Mr. Griffin has done good service by endeavouring to introduce as many new forms of apparatus, or modifications of old forms, from Germany and France, as he could obtain knowledge of.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

The Shrinking of the Earth and Terrestrial Magnetism

SINCE writing my previous letter (vol. ix. p. 141) I have received a note from Mr. Darwin, who says that in his work on "Coral Reefs," he arrived at the conclusion that volcanoes are not found in areas of subsidence. As I have succeeded, I think, in eliminating them from areas of upheaval, it may be that they occupy the boundary line of the oscillating land, and are stationed on or near the fissures and joints along which the earth's crust has given way. At all events, I invite a careful examination of those areas which we know to be rising, such as the northern circumpolar region, Australia, &c., in the firm conviction that volcanoes will not be found on any of them.

On another point I am very glad to say Mr. Darwin agrees with me, and I am therefore supported by his great authority. He tells me that in his work on "Volcanic Islands" he arrived at the conclusion that the great continents are rising, and the ocean beds sinking. This, of course, is only an hypothesis, and will remain so until the world has been carefully surveyed, but the large number of facts I have collected, and which will, I hope, be shortly published, go a long way towards proving it. Accepting this hypothesis, the next question we have to decide is whether the rising of the land is an absolute or a relative rising; whether, in fact, the earth's periphery as a whole is undergoing enlargement or contraction, is stretching or shrinking. To decide this by direct observation is not easy; for water being our only measure, the same effect will be produced either by the sinking of the one portion or the rising of the other, that is, of course, if the rising or sinking be general; while if it be a local rising at one place, it may (as is familiarly known, and as I shall point out presently) be due to the lateral pressure caused by an adjacent subsiding area. In the absence of direct experiment, we may be guided by analogies from other facts. These facts are of two kinds—astronomical and geological.

Since the days of Laplace, the nebular hypothesis has been generally received by astronomers, as the one which best meets observed facts. This hypothesis predicates the existence of gravitation everywhere, and shows how, by its influence, the various heavenly bodies have become condensed from nebular matter. It predicates that this force is still active everywhere, and that everywhere within our observation we have a condensation of matter in progress, matter condensing from a highly diffused condition to one of greater density. Thus each member of our own system, it is argued, is gradually and surely nearing the sun, and at the same time is shrinking, and the various planets are, in fact, in so many stages of evolution, and exhibit for us the various phases which the earth has passed through and will pass through before it is landed in the sun. This is all very elementary. I quote it only to show that the evidence of astronomy is that the earth is contracting, that its periphery is diminishing in area, and that therefore it is probable that the subsidence of the ocean-bed is absolute, while the upheaval of the land is relative only.

Geologists argue differently and yet come to the same conclusion. They argue that the original condition of the earth was an incandescent one, and that it has assumed its present form after a gradual cooling, that is a gradual contraction. In Mr. Geikie's words, recently reported in your pages, "Among the geologists of the present day there is a growing conviction that upheaval and subsidence are—concomitant phenomena, and that viewed broadly, they both arise from the effects of the secular cooling and consequent contraction of the mass of the earth." The evidence of geology, then, is at one with that of astronomy in making the shrinking of the earth absolute and not relative merely.

Now it is very clear that if the shrinking earth acquired a certain amount of rigidity, such shrinking would cease to take place uniformly, and the crust would give way along certain weak lines, and that corrugations, *i.e.* mountain-chains, and deep pits, or ocean hollows, would be formed; and not only so, but the sinking of a given area would give rise naturally to a certain thrust upwards of a contiguous area. To quote the graphic words of Mr. Geikie: "Some portions have sunk more than others. These having to accommodate themselves into smaller dimensions would undergo vast compression and exert an enormous pressure on the more stable tracts which bounded them. It could not but happen that after long intervals of strain, some portions of the squeezed crust would at length find relief from this pressure by rising to a greater or less height according to their extent and the amount of force from which they sought to escape." From this we may conclude (what I have not seen mentioned elsewhere), that from the contraction of the earth alone we may deduce the result that the land areas have been gradually growing larger and the ocean areas smaller; that originally when the crust was less rigid, its surface was almost uniformly level and covered with water, and that as it gradually became corrugated, the land first appeared as an archipelago of islands which were gradually joined together into continents in the way Australia was clearly constructed, comparatively recently; or in other words, that the proportion of subaërial to sub-aqueous deposits must diminish as we recede in geologic time, inasmuch as the area of sea, *i.e.* of water-covered surface, increases.

In this statement of the gradual shrinking of the earth there is little that is new, and if it accounted for all the facts I should not have troubled you with another letter. It has been taken for granted hitherto, if I be not mistaken, that areas of subsidence and upheaval are scattered about the world in a sporadic manner, with as little order and aim as plums in a pudding; that the earth being in process of shrinking, areas of subsidence occur at any point where the earth's crust is weak; but the evidence which I have collected and which I hope the Geographical Society will publish, goes far to show that these areas are not sporadic but continuous, and further, that the foci of upheaval are in the circumpolar regions. That it is there where we meet with proofs of current and rapid upheaval almost at every step, and the farther we go north or south from the equator the more rapid does the rise seem to be, while in the equatorial regions the land masses are to a great extent quiescent; we cannot resist the conclusion that the earth is stretching itself in the direction of its shortest axis, that its periphery is being thrust out in the direction of the Poles. Now as we have shown that the earth is absolutely shrinking and that when any local uprising occurs it is due to the lateral pressure caused by a subsiding area, it becomes interesting to inquire what kind of strain upon the earth would produce a squeezing of it out in the direction of the Poles. I can see only one explanation, namely, that the strain is being applied in the way of a stricture about the world's equatorial region, that it is girdled in that region by some force which is tightening upon it, and this tightening produces a partially compensating protrusion of the two polar regions. I conceive that in a spheroid constructed of partially elastic materials, the effect of such a stricture will cause, besides a sensible diminution of the whole periphery of the sphere, a lateral thrust at right angles to the pressure applied, and thus only can I account for it. This would, if I am not mistaken, have another effect, and this a very important one; it would induce magnetism in the earth, and that magnetism would have its poles in the regions of upheaval, and this is in fact so. The magnetic poles are strictly, so far as our evidence goes, in the very foci of upheaval of the circumpolar regions. This correlation of terrestrial magnetism with the force that is causing a tension about the earth's equator, if sustained would surely go far to explain that crux of physical science referred to by Sir William Thomson in his address to the British Association at Edinburgh, namely, the cause of the earth's magnetism; but my letter has already outgrown reasonable limits, and I must ask you to allow me to continue the subject in another.

HENRY H. HOWORTH

Derby House, Eccles, Jan. 2

Vivisection

IT has been suggested that the study of Huxley's "Elementary Physiology" is likely to make children indulge in cruelty. Allow me to give the experience of the father of five boys on the subject.

Those old enough to be taught from that book are so; and have attended the professor's lectures and seen some of his experiments. The impression left on their minds, from the reverent and touching treatment of the subject by the able professor, has led to an improved and exalted respect for the rights and life of the meanest thing that crawls.

Although these boys are now at what may be called the "predatory age," the interest and respect they evince for animal life is mainly to be attributed to the beautiful and refining lectures of the worthy and humane Huxley.

G. W. COOKE

London, E.C., Jan. 5

Moraines

MR. FRY, writing in NATURE (vol. ix. p. 103), says that "a glacier which has retreated from its terminal moraine is always the source of a stream of water, and this stream always cuts through the terminal moraine." He infers from this that a lake cannot be formed by a moraine damming up a valley.

I can assure him that this is a fact which at least admits of exceptions. The valley of the Kander in the Bernese Alps is, in its upper part at least, full of the moraines of extinct glaciers, now mostly overgrown with pine forest. One of these dams up a side valley and forms the beautiful Oeschinen Lake. The lake is fed from the glaciers of the Blumlis Alp, and its water is consequently muddy. Except in most unusual floods, it has no outlet above ground, but the side of the dam farthest from the lake is one mass of springs of water as clear as the celebrated streams of Lauterbrunnen, which are evidently fed by the water of the lake filtering through the dam. The dam, being a moraine, is of porous material.

JOSEPH JOHN MURPHY

Old Forge, Dunmurry, Dec. 24, 1873

Indian Snakes

I HAVE just had the opportunity of examining the cobra mentioned in my letter dated 12th inst., together with a very handsome one belonging to another snake charmer. This latter cobra also devoured a frog in the space of a minute or two after it was placed in the basket, the frog croaking audibly about half a minute after it was swallowed.

I append the description of these cobras for the benefit of those interested in such matters.

Naja tripudians.—Specimen A.—Colour above very pale olive with pair of conspicuous white, black-edged spectacles. A pair of black H-shaped marks on 12th, 13th, and 14th series (transverse) corresponding to spectacles. Posterior edges of hood above, dark olive. Blackish band 17th to 21st ventral and corresponding scales—rest of belly mottled with dark spots.

Lower anterior temporal in contact with three (3) other temporals.

Ventrals 182, sub-caudals 51, scales 23 series.

Specimen B.—Colour above, olive brown, with numerous pale olive irregular transverse bands and blotches. Belly mottled and barred with blackish. A pair of snow-white, black-edged spectacles. Interstitial skin of anterior central portion of hood pure white, scales pale olive; that of posterior portion and margins black, scales dark olive; colour of hood extending across back in strong contrast to the paler hue of the body.

A pair of white dark-edged spectacles beneath the hood, corresponding to pair above, but the white portion very much wider. Central spots below oval, black, situated on 10th, 11th, and 12th series of scales.

Scales of head pale olive, anterior margins of vertical, supraciliary and occipital shields dark olive, forming a double band across the head. Posterior margins of occipitals dark olive. A vertical infra-orbital streak of dark olive.

Lower anterior temporal in contact with three (3) other temporals. The following ventrals blackish, forming distinct bands 17th to 31st, 24th to 30th, 35th to 38th, 48th to 51st, 61st to 64th all inclusive. Beyond these there are dark bands but the ventrals composing them are not as a rule black throughout.

Ventrals 185, sub-caudals 53, scales 23

Sept. 17, 1873 E. H. PRINGLE

The use of Terms in Cryptogamic Botany

IT seems to me that there is a very perplexing want of uniformity in the names employed by different authors to indicate the reproductive organs of cryptogamic plants.

To a private student this want of formality in the nomenclature of homologous organs is very bewildering; especially when he happens to meet with a term which no botanical work or glossary within his reach explains.

In reading the Rev. M. J. Berkeley's "Introductiou to Cryptogamic Botany," I have come across a term which I cannot find used in the same sense in any botanical work I have consulted.

In the division of algæ called Rhodospermeæ, he says, in speaking of the fruit, "indefinite spores in distinct nuclei."

In *Callithamnion corymbosum* he calls the expanded wall of the mother cell from whose endochrome the walls have been produced by cell division, the nucleus.

In some other genera, he calls the cluster of naked spore-threads the nucleus. In other genera the spore threads arising from a placenta, together with the conceptacles containing them are called a nucleus.

In *Wrangelliaceæ* it is stated that the nucleus is composed of pyriform spores arising from the endochromes of the terminal cells of the spore-threads.

I had first settled in my mind that nucleus was used by Mr. Berkeley as a general name in this disvision of algæ, for an indefinite cluster of spores.

On re-consideration it seemed to me that the term nucleus in the division *Gongylospermeæ* was not applied to the clusters of spores, but to the expanded wall of the mother-cell, or walls of the mother-cells, whose contents had been transformed into spores; and in the great division *Desmiospermeæ* to the spore-threads] from whose cells the spores are produced. Having at length given up this supposition as untenable, it then occurred to me that "nucleus" did not mean the expanded walls of the mother-cells alone, or the clusters of spores alone, or the spore-threads alone; but was a general term applied to the fruit consisting in some cases of spores and spore-threads, in others spores, spore-threads and conceptacles, and in others of the expanded walls of the mother-cells and their contained spores.

When, however, I again read that in *Wrangelliaceæ* the nucleus is composed of radiating pyriform spores, I gave up all attempts at a solution satisfactory to myself.

Can any of your readers inform me what, in this division of algæ, is meant by the term "nucleus," and why it is only used in this division? Did the term not occur in a book written by so high an authority in Cryptogamic Botany it might be passed over as a piece of affectation on the part of the writer. D. R.

POLARISATION OF LIGHT*

III.

WE now proceed to the consideration of the colours produced by plates of crystal when submitted to the action of polarised light. A crystal very commonly used for this purpose is selenite or sulphate of lime, which is readily split and ground into flat plates of almost any required thickness. If such a plate be placed between the polariser and analyser when crossed, it will be found that there are two positions at right angles to each other, in which, if the selenite be placed, the field will remain dark as before. The selenite is, in fact, a doubly refracting crystal, and the positions in question are those in which the plane of vibration of the ordinary ray coincides with that of the polariser (or analyser), and that of the extraordinary ray with that of the analyser (or polariser). In every other position of the selenite, and notably when it has turned through 45° from either of the positions before mentioned, or neutral positions as they may be called, light passes through, and the field becomes bright. If the thickness of the selenite be considerable, the field when bright will be colourless; but if it be inconsiderable, say not more than three millimetres, the field will be brilliantly coloured with tints depending upon the thickness of the plate.

Supposing however that, the selenite remaining fixed, the analyser be turned round, we shall find that in the first place the colour gradually fades as before; until when the analyser has been turned through 45°, all trace of colour is lost. After this, colour again begins to appear; not however the original tint, but its complementary; and in fact, there is no more sure way of producing colours complementary to one another than that here used. A general explanation of this change of colour is already furnished by our former experiments. Doubly refracting crystals generally, in the same way as Iceland spar, divide every ray, and consequently every beam of light which passes through them, into two, so that of every object seen through them, or projected through it on to a screen, two images are produced. These two, being parts of one and the same beam of light, would, if recombined, reproduce the original beam; and the same is, of course, the case with the two images. This may be rendered visible by using the double-image prism as an analyser, and throwing both images on the screen together. As the prism is turned round, it will be seen that, just as when no selenite was interposed, the images are alternately distinguished; but that when both are visible, their colours are complementary. And if the distance of the prism be so adjusted that the images overlap, it will be found that, when both are visible, the part where they overlap is always white, whatever be the thickness of the plate used.

An instructive experiment may be made by interposing an opaque object in the path of the beam of light, so that its shadow may fall upon the part of the field common to the two images. The shadow will of course intercept the light forming each of the images, and will consequently appear double. Suppose that the two images are

* Continued from p. 169.

coloured red and green respectively; then one of the shadows will be due to the shutting off of the red light, and the other to that of the green. But in the first case the space occupied by the shadow will be still illuminated by the green light, and in the second by the red. In other words, neither of the two shadows will be black, one will be green, and the other red. If in any part of their extent the two shadows overlap, the part common to the two, being deprived of both red and green light, will be black.

But in order to explain how it comes to pass that colour is produced at all, as well as to find a more strict proof that the colours of the two images are complementary, we must have recourse to some considerations based upon the wave theory of light. And first as to the mode in which waves may be produced.

Consider a row of balls lying originally in a horizontal straight line. Let the balls start one after another and vibrate at a uniform rate up and down. At each moment some will be at a higher, others at a lower level, at regular intervals in a wave-like arrangement; the higher forming the crests, the lower the hollows of the waves. The distance from crest to crest, or from hollow to hollow, is called the wave length. The distance from crest to hollow will consequently be half a wave-length. This length will be uniform so long as the vibrations are executed at a uniform rate.

Each ball in turn will reach its highest point and form a crest; so that the crests will appear to advance from each ball to the next. In other words, the waves will advance horizontally, while the balls vibrate vertically.

If the row of balls were originally arranged in a wave form, and caused to vibrate in the same way as before, those on the crests would vibrate wholly above, and those in the hollows wholly below the middle line. When the balls originally on the crests rise to their highest points, those in the hollows will fall to their lowest positions, and the height of the wave will consequently be doubled. When the balls originally at the crests fall, those in the hollows will rise, both to the middle line; and the wave will consequently be annihilated. The first of these corresponds to a condition of things wherein the crests of the new wave motion coincide with those of the old, and the hollows with the hollows; the second to that wherein the crests of the new coincide with the hollows of the old, and *vice versâ*.

Hence, when two sets of waves are coincident, the height of the wave or extent of vibration is doubled; when one set is in advance of the other by half a wave length, the motion is annihilated. The latter phenomenon is called *interference*. When one set of waves is in advance of the other by any other fraction of a wave-length, the height of the wave, or extent of vibration, is diminished, but not wholly destroyed; in other words, partial interference takes place. The distance whereby one set of waves is in advance of another is called the *difference of phase*.

The Wave Theory of Light consists in explaining optical phenomena by vibrations and waves of the kind above described. And according to that theory the direction in which the waves move is the direction of propagation of the ray of light.

The intensity of light depends upon the extent of the vibrations or the height of the waves; the colour upon the number of vibrations executed in a given interval of time. And since throughout any uniform medium the connection of the parts and the rate of propagation may be considered to be uniform, it follows that the waves due to the slower vibrations must be longer than those due to the more rapid. Hence the colour of the light may be regarded as depending upon the wave length.

The substance to the vibrations of which light is supposed to be due, is an elastic fluid or medium pervading all space, and even permeating the interior of all bodies. A full statement of the reasons which have led philosophers to make this hypothesis would involve considerations derived from other sciences besides optics, and would be out of place here. But it may still be pointed out that one strong argument is furnished by the fact of the transmission of light from the sun and from the fixed stars through space, where no atmosphere or known gases can be conceived to exist. That the light so traversing interstellar space must be transmitted by a material substance, is a fundamental proposition of mechanical philosophy; and the hypothesis of the ether simply consists in attributing to the substance or medium the property of elasticity (a property possessed in a greater or less degree by all known bodies), without assuming anything else whatever as to its nature or relation to other substances.

In the illustrations of wave motions given above, the balls would represent successive portions or molecules of the ether; and the means whereby the motion of one molecule is transmitted to its neighbour, is the elastic cohesion attributed to the whole medium in the hypothesis above mentioned.

The difference between ordinary and polarised light has been explained above; and the mechanical contrivances devised for representing wave motion always have reference only to polarised light. But as this is the subject with which we are here concerned, the limitation in question is not of consequence. A variety of instruments have been constructed for showing the effects of compounding vibrations or waves under different circumstances. The best with which I am acquainted is that by Sir Charles Wheatstone.

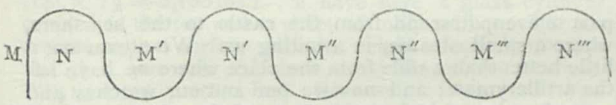
In plane polarised light, such as is produced by tourmalin plates, by double refraction in Iceland spar, &c., the vibrations are rectilinear, and are executed in one and the same plane throughout the entire length of the ray. In circularly polarised light the vibrations are all circular, and the motion is performed in the same direction. In elliptically polarised light the vibrations are all elliptical, the ellipses are all similarly placed, and the motion is in the same direction for the entire ray. These are the only known forms of polarisation, and indeed they are the only forms compatible with the usual, simplest assumption respecting the elasticity of the ether.

These general considerations being premised, we are in a position to trace the course and condition of a ray of light issuing from the lamp or other source, and traversing first the polarising Nicol's prism; secondly, the plate of doubly refracting crystal; thirdly, the analysing Nicol.

The vibrations of the ray on leaving the polariser are all restricted to a single plane. On entering the plate of doubly refracting crystal, every ray is divided into two, whose vibrations take place in planes perpendicular to one another. The angular position of these planes about the axis of the beam of light is dependent upon the angular position of the crystal plate about its centre. The two sets of rays traverse the crystal with different velocities, and therefore emerge with a difference of phase. The amount of this difference is proportional to the thickness of the plate. On entering the analyser the vibrations of each pair of rays are resolved into one plane; and are then in a condition to exhibit the phenomena of interference. If the plane of vibration of the analyser be parallel to one of those of the plate, that ray will be transmitted without change; the other will be suppressed. In any other position of the analyser those monochromatic rays (spectral components of white light whose difference of phase most nearly approaches to half a wave-length, will be most nearly suppressed; and those in which it approaches most nearly to a whole wavelength will be most completely transmitted. The amount of light suppressed increases very rapidly in the neighbourhood of the ray whose difference of phase is exactly a half wave-length; so that with plates of moderate thickness a single colour only may in general terms be considered to be suppressed. This being so, the beam emergent from the analyser will be deprived of that colour, and will in fact consist of an assemblage of all others; or in other words will be of a tint complementary to that which has been extinguished.

Next, as regards the colours of the two images, that is, the two which are formed either simultaneously by a double-image prism or successively by a Nicol in two positions at right angles to one another. In the first place it is to be remembered that the two sets of vibrations into which the selenite has divided the polarised ray are at right angles to one another; secondly, that one set is retarded behind the other through a certain absolute distance, which is the same for every ray, and consequently through a distance which is a different fraction of the wave-length for each colour; thirdly, that these two are re-combined or "resolved" in a single direction in each image by the analyser.

This being so, bend two wires in the following form:—



and place them at right angles to one another about their middle line M N M′ N′.., so that the points M of the two wires coincide, and likewise N, and so on. This will represent the condition of the vibrations as they emerge from the selenite, when the plate is of such a thickness as to cause a retardation equal to one or to any whole number of wave-lengths. Turn the wires about their middle line M N M′ N′ until they meet half way, *i.e.* in a position inclined at 45° to their original directions; this will represent the vibrations as resolved by the analyser in one image. Turn the wires about their middle line as before, but in reversed directions, until they meet in a position at right angles to the former; this will represent the vibrations as resolved by the analyser in the other image. On looking at the wires when so brought together, it will be found that in one case the crests fall upon the crests and the hollows upon the hollows, so that the vibrations combine to increase the intensity of the light. In the other case the crests fall upon the hollows and the hollows upon the crests, so that the vibrations interfere and completely neutralise one another.

The same principle would obtain if we shifted one wire along the middle line so that the points M of the two wires no longer exactly coincide. This would represent the condition of the vibrations as they emerge from the selenite when the plate is of such a thickness as to cause a retardation of a fraction of a wave-length equal to the amount of shift. And on turning the wires as before, we should find that in one image the waves partially combine, and that in the other they partially interfere. The shifting of the wires would represent either the effect of plates of different thickness upon waves of the same length, *i.e.* rays of the same colour; or that of a single plate on waves of different lengths, *i.e.* on rays of different colours. From these considerations we may conclude that the rays which are brightest in one image are least bright in the other; or, in other words, that the colours of the two images are complementary.

It has been remarked that the colour produced by a plate of selenite depends upon the thickness of the plate. In fact, the retardation increases with the thickness, and consequently, if, for a given thickness, it amounts to a half wave-length of the shortest (say violet) waves, for a greater thickness it will amount to a half of a longer (say green) wave, and so on. And if, instead of a series of plates of different thicknesses, we use a wedge-shaped plate, the entire series of phenomena due to gradually increasing retardation will be produced. This is easily seen to consist of a series of tints due to the successive extinction of each of the rays, commencing with the violet and ending with the red. And the tints will consequently have for prevailing hues the colours of the spectrum in the reverse order. This series of colours will be followed by an almost colourless interval, for which the retardation is intermediate between a half red-wave length and three half violet-wave lengths. Beyond this again the series of colours will recur; and the same succession is repeated as the wedge increases in thickness. It will, however, be observed that the colours appear fainter each time that they recur, so that when the thickness reaches a certain amount (dependent upon the nature and retarding power of the crystal) all trace of colour is lost.

It is not difficult to account for this gradual diminution in the intensity of the colours if, by means of a diagram, we examine the mode in which the waves of various lengths interfere with one another; but spectrum analysis furnishes an explanation which is perhaps more easy of general apprehension. If the light emerging from the analyser be examined by a spectroscope, it will be found, in the case of a plate giving the most vivid colour, that the spectrum presents a dark band indicating the colour which has been extinguished. On using thicker and thicker plates the band will be found to occupy positions nearer and nearer to the red end of the spectrum, until the band finally disappears in the darkness beyond the least refrangible rays that are visible to the eye. If the analyser be turned round the band will gradually lose its characteristic darkness, until, when the angle of rotation has reached 45°, the band will have disappeared altogether. The spectrum is then continuous, and when recompounded will give white light. This corresponds to the fact noticed before, that when the analyser is turned round, the colour given by a selenite plate fades and finally disappears when the angle of rotation amounts to 45° If the rotation be continued a band reappears, not, however, in its original position, but in the part of the spectrum complementary to the former.

If the thickness of the plate be further increased, two bands will be seen instead of one; with a still greater thickness there will be three bands, and so on indefinitely. The total light then of which the spectrum is deprived by the thicker plates is taken from a greater number of its parts; or in other words, the light which still remains is distributed more and more evenly over the spectrum, and consequently at each recurrence of the tints the sum total of it approaches more and more nearly to white light.

The following experiment will be found very instructive. Take two wedges of selenite or other crystal, and having crossed the polariser and analyser, place the two wedges side by side in the field of view so as to compare the tints produced by the two. Then place one over the other, first with the thick end of the one over that of the other; next with the thick end of the one over the thin end of the other. If the two plates are exactly similar, the combination in the first instance will be equivalent to a single wedge whose refracting angle is double that of a single wedge; and the number of bands produced will consequently be doubled. In the second combination the angles of the wedges will compensate one another, and the result will be equivalent to a uniform plate whose thickness is equal to the sum of the mean thicknesses of the wedges. The field will then be coloured with a uniform tint, viz., that due to a plate of the thickness in question.

By making use of the principle that the colour produced depends upon the thickness of the plate, selenites have been cut of suitable shapes and thicknesses, so as to produce coloured images of stars, flowers, butterflies, and other objects.

W. Spottiswoode

(*To be continued.*)

*ON THE MOTION AND SENSATION OF SOUND**

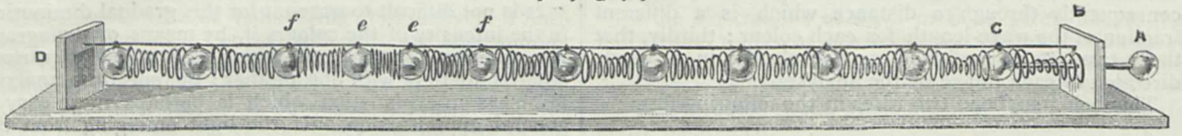
Lecture I.

It is needless for me to say to the ladies and gentlemen who honour these lectures with their presence, that they are intended more especially for the instruction of boys and girls. As in all other cases where it has fallen to my lot to teach others, I shall endeavour, while avoiding superficiality, to strip the subject of all unnecessary difficulty, and of all parade of learning, and to present it in simplicity and strength to the youthful mind.

The title of the lectures is, The Motion and Sensation of Sound. Now every boy knows what I mean when I speak of the sensation of sound. The impression, for example, of my voice at the present time upon the organ of hearing is the sensation of sound. But what right have I to speak of the motion of sound? This point must be made perfectly clear at the beginning.

For this purpose I will choose from among you a representative boy, or allow you to choose him, if you prefer doing so. This boy, whom you may call Isaac Newton, or Michael Faraday, will go with me to Dover Castle, make the acquaintance of the general commanding there, Sir Alfred Horsford, and explain to him that we wish to solve an important scientific problem. He is sure to help us: he will lend us a gun, and an

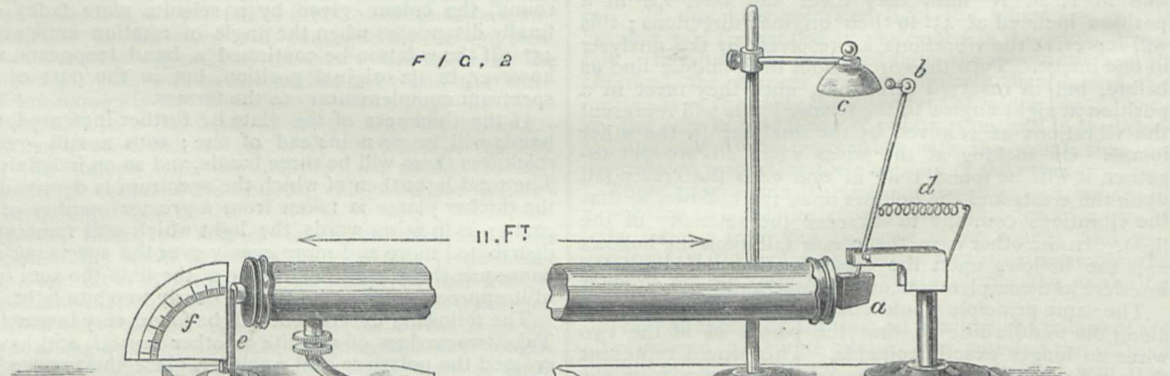
FIG. 1



intelligent artilleryman; and we will make arrangements with this man to fire the gun at certain times during the day. We set our watches together; and now, before quitting him, we ask the artilleryman to fire one shot. We are close at hand, and we observe the flash and listen to the sound. There is no sensible interval between them. When we stand close to the gun flash and sound occur together.

Well, we quit the artilleryman, warning him to fire at the exact times agreed upon. Let us say that the first shot is to be fired at 12 o'clock, the second at 12.30, and so on every half hour. We quit our artilleryman at half-past eleven, descend from the castle to the sea-shore, where a small steamer is awaiting us. We steam out a little better than a mile from the place where we have left the artilleryman; and now we pull out our watches and wait for 12 o'clock. Newton at length says, "In exactly half-a-minute the gun ought to fire;" and, sure enough, at the exact time agreed upon, we see the flash of the gun. But where is the sound which occurred with the flash when we were on shore? We wait a little, and precisely five seconds after we have seen the flash we hear the explosion; the sound having required this time to travel over a little better than a mile.

FIG. 2



We now steam out to twice this distance and wait for the 12.30 gun. We see the flash, but it requires ten seconds now for the sound to reach us; we treble the distance, it requires fifteen seconds; we quadruple the distance, and find the sound requires twenty seconds to reach us. And thus, if the day were clear, we might go quite across to the coast of France and hear the gun there. In all cases we should find that the flash appeared at the precise time agreed upon with the artilleryman, which proves that light reaches us in so short a time that our watches fail to give us any evidence that the light requires any time at all to pass through space, while the sound reaches us later and later the farther we go away. I think these experiments give us every right to speak of the "Motion of Sound."

But they also inform us how the velocity of sound has been actually determined. The most celebrated experiments on this subject have been made in France and Holland. Two stations were chosen ten or twelve miles apart; guns were fired at each station, and the interval between the flash and the report was accurately measured by the observers at the other station. In this way it was found that when the air is at the temperature of freezing water, the velocity of sound through it is 1,090 feet a second. On different days we should find it travelling at different speeds—as the weather grows warmer the sound is found to travel faster.

But I must not let you go with the idea that light re-

* Royal Institution Christmas Lectures, 1873—4, by Professor Tyndall, D.C.L., LL.D., F.R.S. These lectures have not been written out, much less intended for publication. At the request of our Reporter, Dr. Tyndall has consented to their appearance in Nature.

quires no time at all to pass through space. This great problem has also been solved; and we now know that while sound moves at the rate of 1,090 ft. a second, light passes over the almost incredible distance of 186,000 miles in the same time. Hence at the distances employed in our observations, our watches were entirely unable to inform us that light required any time at all to pass through space.

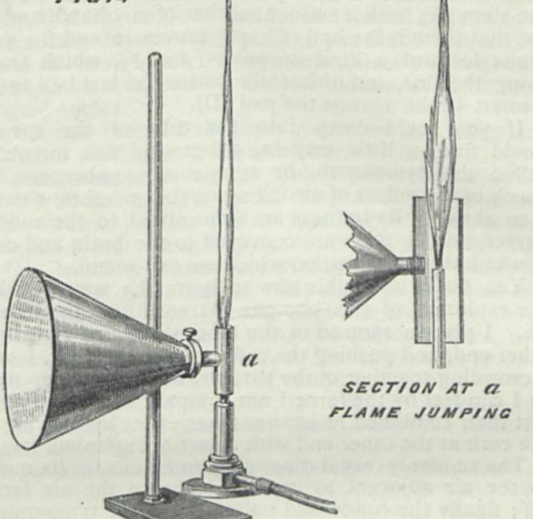
But if I stopped here, your next question would be—What is this thing which passes through the air with a velocity of 1,090 ft. a second, and which, when it reaches us, makes us hear an explosion? We must give a thorough and complete answer to this question, but to do this we need a little preparation. Like sailors going into battle, we must clear our decks for action; and here I must ask you to give me your patient and resolute attention.

In order to know how sound is propagated through the air, we must first know something regarding the air itself. Let us examine the air.

First, the air has weight. It presses upon a single square foot of this table with the weight of nearly a ton ($144 \times 15 = 2{,}160$ lbs.). I have here a glass cylinder covered at the top with a sheet of india-rubber. The air presses on that surface with the weight of nearly 900 lbs. But then you will ask how the india-rubber bears it. Why is it not pressed in? Because air is on both sides of it, and the pressure on the inside is exactly equal to that on the outside. But if I take away the air from the inside of the cylinder, you will soon see the india-rubber pressed down by the weight of air above it.

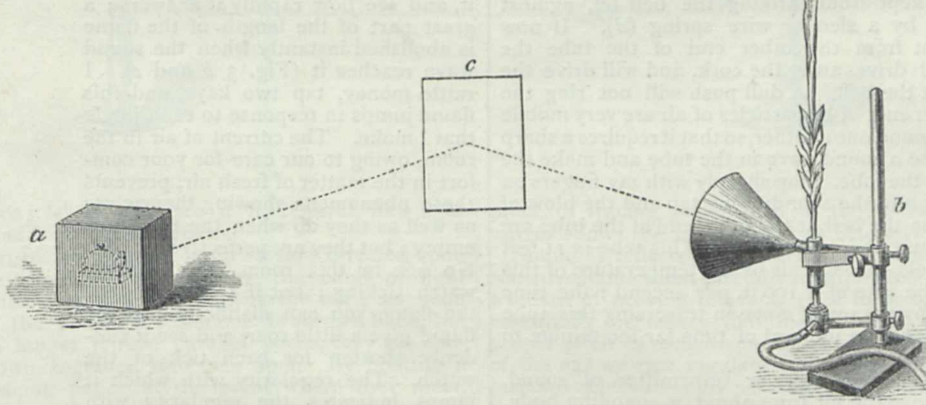
[A tube from an air-pump was then attached to a pipe communicating with the interior of the cylinder,

FIG. 4



which stood on a brass plate, to which its edges were ground parallel; the pump was set in action, and the

FIG. 5.



india-rubber diaphragm at once sank down, in the end clinging to the sides of the glass, forming a deep vessel lining the inside of the cylinder.]

When the air is let in again, you observe the rubber returns slowly to nearly its primitive position; it would entirely, but that the india-rubber is a little over-stretched.

We have thus seen the effect of removing the pressure from the inside. What would occur if we took the outside pressure away? The india-rubber would expand. Instead of trying to remove the whole of the air from this room, which is impossible, I will cover these two slack and collapsed bladders with this glass vessel, fitting accurately on to the plate, over which they are suspended; and then draw off by the air-pump the air surrounding them. See how they gradually blow out; the folds are now nearly abolished; now they have become quite smooth.

Why is this? Because the air particles have the power of pushing one another apart, and thus take up sufficient space to fill the bladders when the external pressure is removed. The air in this room is pressed upon by the weight of the whole atmosphere. The repelling force which the air particles exert upon each other is called the elastic force of the air.

Now we have to consider how the sound of the gun is propagated through air. Does the gun fire anything through the air? No. We may in a rough way represent the particles of air by the solitaire balls arranged in a row close together in this groove. I take the first one and roll it against the second. You observe the row does not move, only the end one goes away. The first delivers up its motion to the second, and then stops, the second delivers its motion to the third, the third to the fourth, and so on until the last, which, meeting no resistance, flies off. In this way we may figure the motion as transmitted from particle to particle of the air.

A still better idea may be derived from this model (Fig. 1), which has been devised by the ingenuity of my assistant, Mr. Cottrell.

In my hand I hold a stem (A), passing through the upright (B), by which a shock can be sent from a ball (C) through a spring to another ball, thence through another spring to another ball, and so on, until at last the shock reaches the last ball, which is projected against the india-rubber pad at the end (D), placed there to represent in a rude mechanical way the drum of the ear. I press the stem (A), with a sudden motion of my hand, and you see that though the ball (C) only moves to and fro, yet it sends forward a kind of pulse (*f e e f*), which travels along the line, and ultimately causes the last ball to give a smart stroke against the pad (D).

If you could creep into the tube of the ear you would find, a little way in, a beautiful fine membrane called the tympanum, or tympanic membrane. The shock of the pulses of air falling on this membrane causes it to shiver; its tremors are transmitted to the auditory nerves, and by them are conveyed to the brain and cause you to have the sensation which we call sound.

You ought to be able now to figure the way in which the explosion of this pop-gun is transmitted through the air. I place a ramrod in the tube, there is a cork in the other end, and pushing the rod towards the cork, I cause a crowding together of the particles of air, this they resist, as I can feel by the force I am compelled to exert, and at last their combined resistance takes effect by blowing out the cork at the other end with a sort of explosion.

The suddenly expanding air communicates its motion to the air adjacent to it; this again to the air farther off; finally the condensed pulse strikes the tympanum of your ears, and you hear the noise.

I can show you the passage of a pulse through air in another way. We have here a tube 11 feet long, and about 4 inches wide, its two ends are closed by thin sheet india-rubber. Against the india-rubber surface at one end a cork gently presses (as in Fig. 2, *a*), to the cork a slender stem is attached having a little hammer at its upper end (*b*), kept from striking the bell (*c*), against which it abuts by a slender wire spring (*d*). If now a pulse be sent from the other end of the tube the india-rubber will drive away the cork, and will drive the hammer against the bell. A dull push will not ring the bell at the farther end. The particles of air are very mobile and readily slip round one another, so that it requires a sharp shock to generate a sound wave in the tube and make the bell ring outside the tube. I tap sharply with my fingers on the india-rubber and the sound of my tap and the blow of the hammer upon the bell at the other end of the tube are audible at one and the same time. This tube is 11 feet long, sound travels through air of the temperature of this room at about the rate of 1,100 ft. per second; the time therefore taken by the sound wave in traversing this tube is $\frac{1}{100}$th of a second, an interval of time far too minute to be measured by our ears.

Air is therefore a carrier or transmitter of sound. Suppose we remove the air from about a sounding body, will it then be heard? This experiment was made by Mr. Hawksbee a great many years ago (1705). A bell with a hammer worked by clock-work is placed under a glass globe. From the globe we will pump as much of the air as we can. At present you hear the sound with perfect distinctness, the pumping has at first apparently little effect upon the sound, but very soon it dies away, and now you see the hammer thumping away upon the bell, without producing any noise. It is doing its work in perfect silence. I allow the air to re-enter the glass globe, the tinkling sound of the bell is soon heard, and quickly grows up into the usual musical ring.

We have therefore proved that when the air is removed we have no sound, and when the air returns the sound returns also.

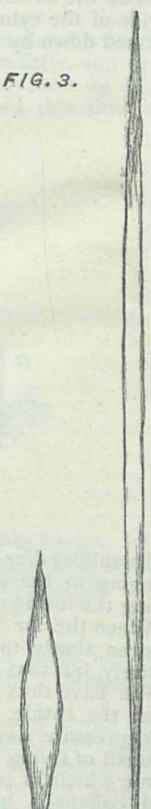
We will now follow the matter up a little further. Prof. Leslie found that when a little air was in the chamber surrounding the bell, and you could hear a little sound, that if the space from which the air had been taken was filled up with hydrogen, that the hydrogen quenched the sound. Now Prof. Stokes has shown us that to create a sound-wave in hydrogen a sharper tap is necessary than in air, so that the shock that produces a sound-wave in air does not suffice to produce a sound-wave in hydrogen (which is a much lighter and less dense gas).

My assistant, Mr. Cottrell, has devised the experiment I am about to show you to demonstrate this effect.

I have a long tin tube (Fig. 2) narrower than the one I used just now, but having like it a piece of india-rubber stretched over each open end, with a hammer and bell arranged against one of them, as before; at the other is a cork hammer fixed to a thin strip of steel, which can be drawn back to any given distance (measured on *f* graduated card). I have thus the means of sending a pulse along the tube as before and making the bell at the other end sound, but I now do it by a stroke of measured force. I now let hydrogen into the tube at the end adjacent to the striking cork (by the tube H), which is a little lower than the other end, and while the hydrogen is entering I continue to send pulses of measured strength along the tube; the bell continues to sound for a little while, but in one minute a sufficient amount of air has been displaced to cause the bell to cease ringing. When we remove the hydrogen you again hear the bell, showing that the pulse can again be carried from end to end of the tube.

Up to this point our illustrations have been audible; I now wish to render visible to you the action of a tube in preventing the dissipation of the sound. The test that I propose to use is a flame. I have behind the table a good-sized gas-holder, by which gas can be forced through a steatite burner. I light it, and we have that long pointed flame (Fig. 3 *a*), and we shall find that that flame is very sensitive. Chirrup to it, and see how rapidly it answers; a great part of the length of the flame is abolished instantly when the sound wave reaches it (Fig. 3 *b* and *c*). I rattle money, tap two keys, and this flame jumps in response to each jingle that I make. The current of air in the room, owing to our care for your comfort in the matter of fresh air, prevents these phenomena showing themselves as well as they do when the theatre is empty; but they are perfectly manifest. No one in this room can hear my watch ticking; but if I hold it near the flame you can distinctly hear the flame give a little roar, and see it suddenly shorten for each tick of the watch. The regularity with which it jumps indicates the regularity with which my watch is ticking.

FIG. 3.



And now observe the action of a tube in preventing the dissipation of sound. Using a less sensitive flame as the sound-test, I take off the india-rubber ends from our 11-foot tube, and place the flame at the end farthest from myself. The tapping of these two keys together does not affect the flame; but now, my distance from the flame being as great as before, I tap them opposite the open end of the tube, and each tap is rendered, by means of the flame, as visible to your eyes as it is audible to your ears.

Through the unconfined air this small bell does not affect the flame when set ringing; but when I place it at the extremity of the tube the flame dances to each stroke. Speaking-pipes possess their value solely from their preventing the dissipation of the sound pulses; they act precisely as this tube does.

As you know, light cannot well get round a corner; neither can sound, though it does so more easily than light. This little bell acts automatically. I wind it up and start it. At a few feet distance the flame answers to each stroke. Placed behind a board, the flame becomes tranquil. I again bring it out from behind the board, and the flame jumps to each movement of the hammer. (For this experiment the sensitive flame was arranged as in Fig. 4, with a large glass funnel having its tubular end opposite the root of the flame; the board was held about 10 feet distant from the mouth of the funnel.) Sound therefore can be shaded off in the same way that light can be.

In this box, which is well padded, is a bell which I can set ringing at pleasure. The only way by which the sound can get out is this small square opening at one side of it. The bell is now ringing without affecting the sensitive flame (arranged as in Fig. 4); but when this box is turned round, so that its opening faces the quiet flame, we have it dancing and jumping as before.

In other respects also there is a similarity between the mode of action of sound and light.

When a beam from the electric lamp is allowed to fall upon the glass mirror in my hand, it is reflected from the mirror, and the track of the beam being marked by the dust floating in the room, you can see the direction which it takes. This is in accordance with a well-known law, namely, that the angle of incidence is equal to the angle of reflection. It is perfectly plain to you that a line drawn so as to fall at right angles upon this mirror would divide that large angle formed by the two beams of light into two equal angles.

I hope now to make visible to your eyes the reflection of sound in obedience to the same law.

At one corner of the lecture table I place our sensitive flame (*b*), at the opposite corner the padded box containing the electric bell (*a*) with its opening directed in the path taken a moment ago by the beam of light, and I will hold this board (*c*), when everything is ready, where I before held the glass mirror. My assistant will now set the bell ringing. You observe that the flame is uninfluenced by it, but when I bring the board forward, the shortening of the flame at each stroke of the bell, proves that the law of the reflection of sound is the same as the law of the reflection of light: the angle of incidence is equal to the angle of reflection. In this case the flame is knocked down by an echo.

We have thus considered the reflection of sound from a plane surface; let us now see if it behaves like light when reflected from plane surfaces.

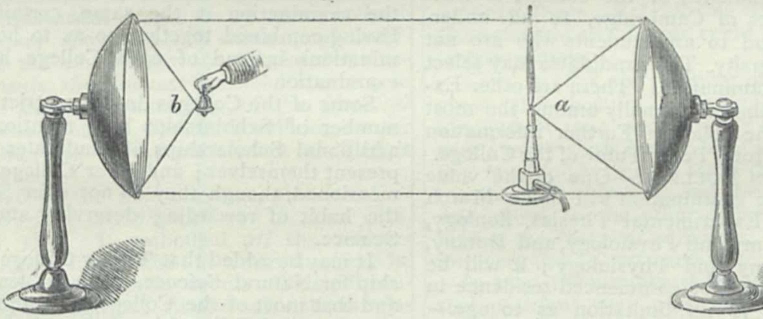


Fig. 6.

The beam of the electric lamp is now directed upon the concave mirror. You can see the band of light marked in the fine dust floating in the air; as soon as it strikes the polished surface it is thrown back, but the rays no longer pursue parallel paths, they are converged, thrown together into one spot. By holding a piece of tracing paper at the point where they meet, termed the focus, the brilliant little star of light caused by their convergence is made visible.

Substitute for the lamp a small bell, and for the tracing paper at the focus of the mirror our sensitive flame, and the conditions are the same as in the previous experiment, sound-waves taking the place of the waves of light. You cannot see the track of these aërial pulses as you could the luminous ones, but their obedience to the same law of reflection is very manifest by the shortening of the sensitive flame as each sound wave reaches it. The flame when out of the focus of the mirror is unaffected; replace it in the spot when the sound waves are crowded together, and it responds to each stroke. Move the bell so that the sound pulses, though only having the same distance to travel to the flame, no longer fall on the mirror: the flame remains perfectly quiet.

We may go further still. Here are a pair of mirrors, the curvature and size of which is the same. They are arranged so as to face one another. A light is placed in the focus of one, that its rays which fall divergent upon the curved surface are reflected from it parallel, they travel to the opposite mirror, and are again converged; a piece of tracing paper held at the focus of the farther mirror shows the spot of light as before (Fig. 6).

Sound is reflected in precisely the same way, and the sensitive flame when carefully manipulated can be used as a means of proving this fact. For these experiments it is essentially necessary that the flame be reduced to the proper pitch of sensitiveness. By reducing the pressure of the gas we can regulate the flame so that it will not respond unless strongly agitated. The flame is placed in the focus of the mirror (*a*), and when the bell is rung, not being in the focus of the conjugate mirror, there is no action. I now bring it into the focus (*b*) and the flame shows a very strong action.

By other modes of experimenting it has long been ascertained that sound was thus reflected from plane and curved surfaces; but never before have these phenomena been made visible. Hitherto these effects have been investigated by the sense of hearing; I have now been able to prove them by appealing to your eyes.

(*To be continued.*)

SCHOLARSHIPS AND EXAMINATIONS FOR NATURAL SCIENCE AT CAMBRIDGE, 1874

THE following is a list of the Scholarships and Exhibitions for proficiency in Natural Science to be offered at the several Colleges in Cambridge during the present year:—

Trinity College.—One or more of the value of about 80*l.* per annum. The examination will commence on

April 10, and will be open to all undergraduates of Cambridge and Oxford, and to persons under twenty who are not members of the Universities. Further information may be obtained from the Rev. E. Blore, Tutor of Trinity College.

ST. JOHN'S COLLEGE.—One of the value of 50*l.* per annum. The examination (in Chemistry, Physics, and Physiology, with Geology, Anatomy and Botany) will be in December, and will be open to all persons who have not completed a term of residence at the University, as well as to all who have entered and not completed one term of residence. Natural Science is made one of the subjects of the college examination of its students at the end of the academical year, in May; and Exhibitions and Foundation Scholarships will be awarded to students who show an amount of knowledge equivalent to that which in classics or mathematics usually gains an Exhibition or Scholarship in the college. In short, natural science is on the same footing with classics and mathematics, both as regards teaching and rewards.

CHRIST'S COLLEGE.—One or more, in value from 30*l.* to 70*l.*, according to the number and merits of the candidates, tenable for three-and-a-half years, and for three years longer by those who reside during that period at the college. The examination will be on March 24, and will be open to the undergraduates of the college, to non-collegiate undergraduates of Cambridge, to all undergraduates of Oxford, and to any students who are not members of either University. The candidates may select their own subjects for examination. There are other Exhibitions which are distributed annually among the most deserving students of the college. Further information may be obtained of Mr. John Peile, Tutor of the College.

GONVILLE AND CAIUS COLLEGE.—One of the value of 60*l.* per annum. The examination will be on March 24, in Chemistry and Experimental Physics, Zoology, with Comparative Anatomy and Physiology, and Botany, with Vegetable Anatomy and Physiology; it will be open to students who have not commenced residence in the University. There is no limitation as to age.—Scholarships of the value of 20*l.* each, or more if the candidates are unusually good, are offered, for Anatomy and Physiology, to members of the College.—Gentlemen elected to the Tancred Medical Studentship are required to enter at this College; these Studentships are five in number, and the annual value of each is 100*l.* Information respecting these may be obtained from Mr. B. J. L. Frere, 28, Lincoln's Inn Fields, London.

CLARE COLLEGE.—One of the value of 60*l.* per annum, tenable for two years at least. The examination (in Chemistry, Chemical Physics, Comparative Anatomy and Physiology, Botany with Vegetable and Animal Physiology, and Geology) will be on March 24, and will be open to students intending to begin residence in October.

DOWNING COLLEGE.—One or more of the value of 40*l.* per annum. The examination (in Chemistry, Comparative Anatomy, and Physiology) will be early in April, and will be open to all students not members of the University, as well as to all undergraduates in their first term.

SIDNEY COLLEGE.—Two of the value of 40*l.* per annum. The examination (in Heat, Electricity, Chemistry, Geology, Zoology and Physiology, Botany) will be on March 24, and will be open to all students who intend to commence residence in October.

EMMANUEL COLLEGE.—One of the value of 70*l.* The examination on March 24 will be open to students who have not commenced residence.

PEMBROKE COLLEGE.—One or more of the value of 20*l.* to 60*l.*, according to merit. The examination in June, in Chemistry, Physics, and other subjects, will be open to students under 20 years of age.

KING'S COLLEGE.—One of the value of about 80*l.* per annum. The examination, on April 14, will be open to all candidates under 20, and to undergraduates of the college in their first and second year. There will be an examination in elementary Classics and Mathematics, in addition to three or more papers in Natural Science, including Physics, Chemistry, and Physiology.

Although several subjects for examination are in each instance given, this is rather to afford the option of one or more to the candidates than to induce them to present a superficial knowledge of several. Indeed, it is expressly stated by some of the colleges that good clear knowledge of one or two subjects will be more esteemed than a general knowledge of several.

Candidates, especially those who are not members of the University, will, in most instances, be required to show a fair knowledge of Classics and Mathematics, such, for example, as would enable them to pass the previous examination.

There is no restriction on the ground of religious denominations in the case of these or any of the Scholarships or Exhibitions in the Colleges or in the University.

Further information may be obtained from the Tutors of the respective Colleges; and the names, with certificates of character, date of birth, &c., must be sent to the Tutor of the College, in each case, several days before the examination.

It will be observed that in several instances the time of the examination is the same, certain of the Colleges having combined together so as to hold one or two examinations instead of each College holding a separate examination.

Some of the Colleges do not restrict themselves to the number of Scholarships here mentioned, but will give additional Scholarships if candidates of superior merit present themselves; and other Colleges than those here mentioned, though they do not offer Scholarships, are in the habit of rewarding deserving students of Natural Science.

It may be added that Trinity College will give a Fellowship for Natural Science, once, at least, in three years: and that most of the Colleges are understood to be willing to award Fellowships for merit in Natural Science equivalent to that for which they are in the habit of giving them for Classics and Mathematics.

*ASTRONOMICAL ALMANACS**

X.—*Remodelling of the "Nautical Almanac" and the "Jahrbuch."*

NEARLY all the reforms which concerned astronomy were realised by Encke in the *Jahrbuch* for 1830, which appeared in May 1828. The appearance of this volume created an enormous sensation in England. The contest between Young and his opponents was then at its height. Strengthened by the help which had come to it from Berlin, the Astronomical Society redoubled its complaints and renewed its action; but the death of Thomas Young (May 10, 1829) soon occurred to simplify matters. In order that the question might not be hastily decided, the Society got the *Nautical Almanac* provisionally entrusted to the care of the Astronomer-Royal, J. Pond; at the same time it appointed a commission of forty members, composed of the directors of all the observatories and the principal astronomers and mariners, English and foreign.†

At last, at its annual meeting in February 1830, the Society awarded to Encke its gold medal for the great service which he had rendered to astronomy. "It would be superfluous," said Sir James South, President of the Society, in the address which he gave on that occasion, "for us to enlarge upon the merit of this well-known work, which, beyond all rivalry, ought to be regarded as the only ephemeris on a level with the requirements of

* Continued from p. 49.

† Struve took part in this commission.

Science, as the manual and guide of practical astronomy, wherever it may be cultivated."

But if the English are impartial and generous towards strangers, they could not bear to be for any time inferior in the various services which touch upon their interests. The sub-committee * charged with preparing the plan for reorganising the *Nautical Almanac*, presented its report to the Society at the meeting of November 19, 1830, a report which was adopted by the Council and immediately approved by the Admiralty. The results of this beneficial agitation were of immense value to astronomy and navigation, and the improvements introduced were such that, even from an astronomical point of view, the *Nautical Almanac* easily surpassed the *Jahrbuch*, and from a maritime stand-point it has not yet been equalled.

First of all, it should be stated that the Commissioners laid down as an absolute rule, a rule which has ever since been scrupulously followed, that the *Nautical Almanac* ought to appear four years in advance of the year for which it is calculated. Moreover, the direction of the *Nautical Almanac*, while continuing under the jurisdiction of the Admiralty, was entrusted thenceforth to a single person, the Superintendent of the *Nautical Almanac* Office.

The *Nautical Almanac* has been from that time in reality a special scientific institution, having its offices and its library established in a separate building. The salary of the superintendent was fixed at 500*l.*, and the annual parliamentary allowance was made amply sufficient to permit of the employment of calculators numerous enough to insure the greatest possible accuracy in the results. The first superintendent of the *Nautical Almanac* office was Lieut. S. Strafford, well known for the part which he took in the publication of Baily's "Zodiacal Catalogue."

The first volume of the new almanac, the *Nautical Almanac and Astronomical Ephemeris for the Year* 1834, appeared in July 1833. It embodied *all* the reforms which we have already mentioned; it would therefore be useless to indicate its contents in detail. We shall content ourselves with adding, that all the calculations relative to the principal planets were made under the direction of Schumacher of Altona, and those relating to the telescopic planets by the celebrated Encke. Moreover, as it is absolutely essential that a single list of stars of the moon should suffice navigators of all nations, the Royal Society came to an understanding with Encke on this subject. The stars of the moon ("moon's culminating stars"), ceased from that time to figure in the *Jahrbuch*, and the *Nautical Almanac* obtained the monopoly of this useful publication, a monopoly which it has since preserved.

The tables employed were nearly the same in the *Jahrbuch* and the *Nautical Almanac*. For the sun there were the new tables of Carlini, with the corrections of Encke and Bessel; for the moon the tables of Burckhardt; for Mercury, Venus, and Mars, the tables of Von Lindenau, with the corrections of Schumacher; for Jupiter, Saturn, and Uranus, the tables of Bouvart; for the satellites of Jupiter, the new tables of Delambre, with the corrections of Jenkins and Woolhouse.

XI. *The "Connaissance des Temps" since* 1832.

While this great work of reform and renovation was being carried on, the Bureau des Longitudes of France did not remain inactive. "The Bureau have recently appointed a commission, chosen from its own members, to examine some modifications which it would be expedient to introduce into the *Connaissance des Temps*. In considering this object, the commission has not lost sight of the fact that it is dealing with a work specially designed for mariners, with which they have been familiar for many years, and of which it was, above all, desirable that the price should not be increased." *

On the one side maritime necessities required that the *Connaissance des Temps* should, like the *Nautical Almanac*, appear four years in advance; although for long it has been published on an average only a year and a half before its date, being a delay of two years and a half. On the other side, the ephemeris then published by the *Connaissance des Temps* was evidently insufficient for French astronomers; the following modifications were therefore adopted, and were completely embodied in the *Connaissance des Temps* for 1835.

The mean time was the only time used (although astronomers needed the equatorial co-ordinates of the sun for true noon); the co-ordinates expressed in time were given at $0^{s}\cdot 01$, and those in arc, $0''\cdot 1$; the latitude and longitude of the moon were given for midnight and noon of each day; to the lunar distance were added those of the planets Venus, Mars, Jupiter, and Saturn; lastly were given for every tenth day, the apparent positions of sixty-four fundamental stars (the *Nautical Almanac* gave 100).

On the other hand, as it came to be seen that the solar tables of Delambre were defective, the Bureau invited Savary to amend them, but all he did was to remedy errors here and there by means of the corrections of Bessel. Moreover, Delambre's tables of satellites having been discontinued till 1840, Damoiseau was ordered to continue them. But all this was so insufficient, that the *Connaissance des Temps* could not be more serviceable to astronomers.

Thus, in 1838, the positions of the planets, which were given until then for every tenth day, were calculated to a minute of time and of arc; every third day for Mercury; every sixth day for Venus and Mars; every seventh day for Jupiter; every tenth day for Saturn; every fifteenth day for Uranus; and the value of the radius vector was added to the other elements. This was very far behind the *Nautical Almanac*, which gave the positions for every day to $0^{s}\cdot 01$ and $0''\cdot 1$.

In 1849, the number of fundamental stars whose apparent positions were given was carried to 115, and the apparent position of α Ursæ Minoris, was given for every day in the year. The *Nautical Almanac* had given those of α and δ Ursæ Minoris for 1834.

In 1854, M. Mathieu was specially appointed to the editorship of the *Connaissance des Temps*. Very soon after he entered upon his duties he had to sustain an attack which recalls that already referred to between Young, Baily, and Sir James South. For some years a sharp controversy was maintained between M. Mathieu and M. Leverrier, and at length the *Connaissance des Temps* of 1862 published for the first time the positions of the moon for every hour, with the differences for 10 minutes. "This innovation," the learned editor said, "is valuable to mariners; it simplifies the calculations of interpolation, and now sailors will be able to make use of the ephemeris of the moon with as much ease as that of the sun." The calculations of the moon are, moreover, made according to the tables of M. Hansen,† which the *Nautical Almanac* had employed since 1858. Lastly, in the same year, are given the positions of δ Ursæ Minoris for every day.

In the following year the ephemeris of the planets was improved, and there were given for every day the heliocentric and geocentric positions at mean noon of Mercury, Venus, Mars, Jupiter, and Saturn; for Uranus and Neptune the positions were calculated only for every fourth day. This was in imitation of a modification suggested by Mr. (now Sir G. B.) Airy to the superintendent of the *Nautical Almanac*, and applied by him from 1857 (*Almanac* for 1861). But, since 1839, besides the pre-

* Composed of Sir James South, president, F. Baily, reporter, C. Babbage, Capt. F. Beaufort, J. F. W. Herschel, J. Pond, Rev. Dr. Robinson, Lieut. S. Strafford, W. Struve.

* Advertisement of the *Connaissance des Temps* for 1832.

† "Tables of the moon constructed according to the Newtonian law of Universal Gravitation," by P. A. Hansen, Director of the Ducal Observatory of Gotha. (Printed at the expense of the British Government, 1857.)

ceding information, the *Nautical Almanac* gave, first for every day, and from 1861 for every two days, the ephemerides of all the planets for the time of their passing the meridian of Greenwich, information which French astronomers would have been happy to find in the *Connaissance des Temps* for the meridian of Paris. Let us add, moreover, that the positions of Neptune were only given in the *Connaissance des Temps* in 1861 (for 1863), while they were in the *Nautical Almanac* from 1857 (for 1861).

It was also in this same year, 1863, that the *Connaissance des Temps* gave for the first time the values of the constants of Bessel, intended to transform into apparent positions the mean positions of the stars given by the catalogues; as well as the elements of the occultations, according to Bessel, in a form which enabled voyagers to calculate, for the very place where they happened to be, the principal circumstances of the phenomena. The *Nautical Almanac* had published all this since 1834.

In 1864, the positions of the sun, which for many years were calculated with the tables of Delambre, reconstructed in part by M. Mathieu, were published according to the tables of M. Leverrier; the same was done for the positions of Mercury, and in the following year for those of Venus and Mars. The *Nautical Almanac* had used the tables of M. Leverrier since 1860 for the sun and Mercury (*Almanac* for 1864), since 1861 for Venus (*Almanac* for 1865), since 1862 for Mars (*Almanac* for 1866). On the other hand, the *Connaissance des Temps* for 1864 appeared in February 1863, and consequently six months after the *Nautical Almanac* for 1866. Finally, the *Connaissance des Temps* for 1864 contained the rectilinear co-ordinates of the sun referred to the plane of the equator; they are found in the *Nautical Almanac* from 1849.

This collection of reforms raised considerably the value of the *Connaissance des Temps*, which, it was unanimously agreed, had fallen very low as compared with foreign ephemerides. The reform accomplished in France in 1864 was analogous to that of the *Jahrbuch* in 1829 and of the *Nautical Almanac* in 1830. But even at the present time the *Connaissance des Temps* does not contain any ephemeris of Ceres, of Pallas, of Juno, nor of Vesta, which has appeared in the *Nautical Almanac* and the *Jahrbuch* since 1830; nor of any of the numerous small planets discovered since 1845, for which the other two works publish a supplement each year. Yet for a long time past the continued observation of these telescopic planets has formed one of the most important occupations of most of the observatories.

In 1870 the direction of the *Connaissance des Temps* passed into the hands of Puiseux, who, however, kept it for only a very short time. His period of office, nevertheless, was marked by an important improvement. He indicated, by a figure in the proper place, the day on which, in consequence of the difference of length between the sidereal day and the mean solar day, each star passed twice across the superior meridian of Paris. This was a sad omission; such an indication is found in the *Nautical Almanac* for 1822.

At present the direction of the *Connaissance des Temps* is entrusted to M. Lœwy; Mr. Hind has been superintendent of the *Nautical Almanac* Office since 1853, and Herr Fœrster succeeded, in 1864, the celebrated Encke in the direction of the *Jahrbuch* of Berlin.

TELEGRAPHING EXTRAORDINARY

AT the Telegraph Office, Washington, on Dec. 11, 1873, an experiment was carried out in the presence of Mr. Creswell, the Postmaster-General of the United States, the practical results of which will be of immense importance as regards the future of telegraphy throughout the world.

On that occasion the president's last annual message of 11,500 words was transmitted from Washington to New York, a distance of 290 miles, over a single wire in 22½ minutes, the speed obtained being over 2,500 letters per minute.

At New York the message was delivered from the automatic instrument printed in bold type in presence of the Postmaster of New York. This achievement in telegraphy is the more remarkable as the principle involved is not new, but was well known in 1848. The experiments made at that date were practically without result. By the new American combination of chemistry and mechanism the speed is apparently almost unlimited, messages at the rate of 1,200 words, or 6,000 letters, a minute being afterwards transmitted with equally satisfactory results.

Hitherto the speed attainable over circuits of similar length in this country by the Wheatstone automatic system, at present in use for the "high speed" service by the Postal Telegraph Department, does not exceed 200 letters a minute.

The new American instrument has a great advantage in the extreme simplicity of its construction, mechanical detail giving place to chemical action. One important result of this experiment is that it demonstrates that hitherto the speed of transmission of electric currents through a metallic conductor has been restricted from mechanical imperfections in the mechanism of the recording or receiving instrument, and that by the substitution of chemical decomposition for mechanical action, an almost unlimited speed of transmission may be obtained. It is to be hoped that this new transmitting and recording instrument may be the agent by which our present tariff of 1*s*. for twenty words, may be reduced to 6*d*., or less, for a similar message. Scientific progress, practically applied, is an heirloom to a nation.

NOTES

MR. HENRY LONSDALE is preparing a biography of John Dalton, the great chemist, and would be glad of any letters or other aid in his important work.

AT the meeting of the Paris Academy of Sciences held on Monday, January 5, M. Fremy was elected president for the ensuing year, and MM. Chasles and Decaisne were elected to serve on the central committee.

A COMMITTEE, consisting of Lord Cathcart, Mr. C. Whitehead, Mr. Jabez Turner, Mr. Wakefield, Mr. Brandreth Gibbs, Mr. J. Bowen-Jones, Mr. W. Carruthers, F.L.S., and Mr. J. Algernon Clarke, appointed by the Royal Agricultural Society to carry into effect the suggestions of the judges of the potato disease essays held a meeting on Monday at Hanover Square. They will recommend the Council to offer three prizes of 100*l*. each for disease-proof potatoes. Competitors will probably be required to send in one ton of each variety by the middle of February. Each sample will be distributed among growers in many different parts of England, Wales, Scotland, and Ireland; and the produce of potatoes which resist disease during the first year's trial will be tested for two years longer. With a view of encouraging the production of new varieties, handsome prizes are to be offered also for disease-proof sorts raised from potato plums to enter into competition in the spring of 1879. The terms and conditions will be decided upon at the next meeting of the Council.

THE INDIAN MUSEUM, as it now stands, situated on the highest story of the India Office, has been found to be useless for all the purposes for which it was intended. It has therefore been resolved to erect on the plot of vacant ground in Charles-street, directly opposite the India Offices and facing St. James's Park, a new museum and public library. To this building, which will be very handsome and commodious, all the treasures exhibited in the present museum, as well as those now stowed away for want of space, will be removed. The public library and reading-room will form a marked feature in the new building, and will be constructed more especially with a view to the wants of those preparing for competition in the Indian Civil Service Examinations.

A STATEMENT, drawn up by the Council of the Trades Guild of Learning describes at great length the objects which are contemplated by the organisation. It states that its purpose is to provide education for workmen (1) in the sciences underlying their respective industries, and (2) in various branches of higher education; and that it has sprung spontaneously from the workmen of this country, and its responsible direction will devolve in the main on them, with the support of others who can undertake to advise and help in their educational work. It will accept of no aid from the State, but will make use of the National Universities as the best source of general education for the people of the great towns, enabling them to acquire, not only the results of scientific research, but the most thorough and scientific methods of teaching. By means of branches, which it proposes to establish in the large towns, it hopes to supply what is required to render the work already begun by the University of Cambridge continuous and permanent. It will endeavour to form local Boards, consisting mainly of workmen, who will be responsible for the preliminary formation of classes and the collection of the funds necessary in order to obtain University teaching.

DR. SMALLWOOD, one of the oldest meteorological observers in Canada, and Professor of Meteorology in McGill University, died on December 22. He had carried on observations for more than thirty years; in the first instance at St. Martin's, and afterwards, under the auspices of McGill University and the Canadian Government, in Montreal.

THE Geological Parties of the Canadian Geological Survey and the Boundary Commission have now returned from the West, bringing much material of scientific interest. One of the most important practical results appears to be the establishment of the existence of very large and valuable beds of coal and lignite in various parts of the Canadian territory, between Red River and the Rocky Mountains. This must greatly promote the settlement of these territories and the extension of railway communication into them.

THE *XIX^e. Siècle* announces that one of the most distinguished officers of the French navy, as well as an eminent explorer, M. F. Garnier, has been assassinated by the Chinese rebels of Tonquin. It would appear that M. Garnier was in the month of November last engaged in an expedition in Tonquin, his object being to enforce the treaties by expelling from the country a Frenchman who had supplied arms to the people of Yun-nan. M. Garnier had captured a town and made prisoners, who are now on their way to France. It is possible that he fell in a subsequent engagement, but the telegram distinctly states that he was assassinated. On this point full details are expected to arrive on the 18th or 20th inst. M. Garnier was only 35 years of age, having been born at St. Etienne on July 25, 1839. Appointed a midshipman in 1860, he was attached in the same year to the staff of Admiral Charner, and in that capacity he made the campaigns of China and Cochin China. Three years later he was appointed Inspector of Native Affairs, and soon afterwards he published a pamphlet in which he propounded an elaborate scheme for an exploring expedition into the interior of Indo-China, with a view to the opening up of commercial communications between Southern China and the French possessions. M. de Chasseloup, at that time Minister of Marine, nominated a scientific commission to carry out this expedition, the importance of which he fully appreciated. On June 5, 1866, an expedition, under the command of Capt. de Lagrée, and comprising among other officers Lieut. Garnier, left Saigon, went up the river Me-Kong, explored Indo-China, and proceeded as far as Yunnan. After the death of his chief, Lieut. Garnier assumed the command of the expedition, which he brought back to Saigon, along the Blue River. This voyage of exploration, one of the most important which has been accomplished in the present century, occupied two years and a few days. The death of this young and intrepid traveller is an irreparable loss for France and for the whole scientific world.

LAST Thursday, Sir Bartle Frere, speaking at Glasgow on Dr. Livingstone, said that he was often asked what benefit and practical result he expects from Dr. Livingstone's labours. "I answer," Sir Bartle Frere said, "that the geographical problems alone which he will have solved must exceed in importance and interest those of any other explorer since the days of Columbus. But apart from all questions of geographical science, I believe that the commercial, political, and moral consequences must prove far more important than anything of the kind which has been effected since the discovery of the New World."

THE members of the Cambridge Natural Science Club concluded their fifth series of meetings on Saturday, December 6. Each member in turn brings some subject of scientific interest before the notice of the club, in the form of a paper or otherwise, and the discussions which follow have been in many cases both lively and prolonged. The following subjects were discussed during the October Term, 1873:—"Mechanics in Nature," by Mr. A. F. Buxton (Trin. Coll.); "Zoological Colonies," by Mr. A. J. Jukes Browne (St. John's Coll.); "The Magnetism of Crystals," by Mr. J. E. H. Gordon (Caius Coll.); "Some Transformations of Energy," by Mr. C. T. Whitmell, B.A. (Trin. Coll.); "The Neocomian Strata," by Mr. J. J. H. Teall, B.A. (St. John's Coll.); "Cone in Cone-structure in the Lower Silurian Rocks," by Mr. R. D. Roberts (Clare Coll.); and a paper on "The Continuity of the Chalk," read by Mr. P. H. Carpenter.

IN the last number of the *Journal* of the Scottish Meteorological Society is a paper by Prof. Mohn on "Certain Effects of Currents on the Temperature of the Sea and Air," of which the following are the results:—1. That the surface of the sea in currents in narrow sounds in summer is colder than in neighbouring places, where there is a wider sheet of water. 2. That an effect of the reverse kind takes place iu winter, but in a much smaller degree. 3. That both effects together diminish the yearly range of the temperature of the surface of the sea. 4. That these circumstances influence the temperature of the air in the same direction at such places, and that hereby a part of the anomalous, strongly-marked oceanic character which places in such situations exhibit, is accounted for. Other papers in this number are—"Letter on some Meteorological Questions requiring Investigation," from Mr. Robert Tennent; and a valuable paper on "Atmospheric Ozone and its Sources," by Dr. T. Moffat.

MESSRS. MACMILLAN have issued a cheap "Special Edition for Schools," of Edward Clodd's "Childhood of the World," in the style of the "Science Primers."

THE Meteorological Committee of the Royal Society have considered Mr. Meldrum's "Notes on the form of Cyclones in the Southern Indian Ocean, and on some of the rules given for avoiding their Centres," of so much practical importance, that they have thought it right to print and circulate it in a separate form as a non-official paper.

WE can do little more than name the following books which have been sent us:—Professor Blackie's neat little volume "On

Self-Culture, Intellectual, Moral, and Physical, a Vade-mecum for Young Men and Students" (Edinburgh: Edmonston and Douglas), contains many old and valuable truths forcibly expressed, and is calculated, we believe, to benefit the class for whom it is intended.—"Darwinism and Design; or, Creation by Evolution" (Hodder and Stoughton), is an attempt to show that although "Evolution is true, the Design argument remains unshaken;" that indeed "Evolution is the method of Creation."—"From January to December; a book for Children" (Longmans), is a miscellany consisting of stories, poems, papers on natural history, &c., arranged, for no reason that we can see, under the twelve months of the year. We fear even grown-up children will find the visits to Kew, the Zoological Gardens, and other papers, dull; besides, it is a great blunder to send forth a book like this without a single illustration.—"The Alps of Arabia; Travels in Egypt, Sinai, Arabia, and the Holy Land," by William Charles Vaughan (King and Co.), goes over well-trodden ground, and tells us nothing new; though those who contemplate a similar journey will find the book u eful, fresh, and interesting.—"The Expanse of Heaven; a Series of Essays on the Wonders of the Firmament," by R. A. Proctor, B.A. (King and Co.), is sufficiently described by its title.

"GEOLOGICAL Sketch of the Province of Cadiz," by J. McPherson, is an abstract of a similar work written by the author in Spanish, and is printed at Cadiz. It is a valuable study of the subject, and is illustrated by well-executed maps and sections.

WE take the following from *Ocean Highways*:—Captain Heaviside, R.E., of the Great Trigonometrical Survey of India, is completing the work of Captain Basevi by forming a base station for the India pendulum operations, at the Kew Observatory. With this object he is now engaged in swinging Captain Kater's original convertible pendulum; and a re-measurement of its length will be undertaken probably at the Ordnance Survey Office at Southampton, by Colonel Clarke, the highest authority in England, and probably in Europe, as regards the measurement of standards.

THE Dublin College of Physicians, the *Lancet* says, has opened its portals to female aspirants for its degrees, a lady holding the M.D. of Zurich having been exempted from the first half of the examination for the L.K.Q.C.P. The College is also said to be willing to confer its midwifery diploma on all ladies who may, under certain regulations, apply for it.

WE have received an Italian publication by A. Manzone, on the fossils of Monte Titano in the republic of San Marino, their age and mode of origin. It is published at Florence by G. Barbèra.

THE principal papers in the last number of Petermann's *Mittheilungen* are, a Memoir of Colonel Eemel von Sydow a long account, by Prof. Nordenskiöld, of the Swedish Expedition to the North-east of Spitzbergen, from April 24 to June 15, of last year, an account of the Exploration of North-west Texas, by an expedition sent out in 1872 by the Texas Land and Copper Association, and a summary of the work of the *Challenger* Expedition in the North Atlantic. The last two are illustrated by well-executed maps.

THE additions to the Zoological Society Gardens during the past week include a Lioness (*Felis leo*) from Kattywar, presented by Mr. J. Humfrey, of the Bombay Staff Corps; three common Marmosets (*Hepale jacchus*) from S.E. Brazil, presented by Le Chevalier d'Albuquerque; a Crested Ground Parrakeet (*Calopsitta novæ-hollandiæ*) from Australia, presented by Vice-Admiral Wallis Houston; and a Drill (*Cynocephalus cucophœus*) from W. Africa, purchased.

SCIENTIFIC SERIALS

The Monthly Microscopical Journal, for this month, contains four papers, besides the notes, record of the progress of Microscopical Science and the Proceedings of the Royal Microscopical Society.—Mr. S. J. McIntire, in Notes on so-called *Acarellus*, discusses the point whether the specimens described and named *A. muscæ* and *A. pulicis*, by Mr. Tatem, are related to a form known by him as a parasite on *Obisium*, and elsewhere; and whether it is one of the early forms of *Gamasus*, as thought by Mr. Tatem and Dujardin, though not by himself.—A second paper by Mr. W. H. Dallinger and Dr. J. Drysdale, contains further researches into the life-history of the Monads. The importance of prolonged study of the same form is insisted on, and this shows that the method of multiplication is not, as generally supposed, entirely by fission, but sometimes by an absorption into one of two individuals, the resulting mass clearing like an ovum, and giving rise, somewhat as in *Gregarina*, to a multitude of new individuals. Sometimes more than two, as many as four or six, were observed to unite.—Prof. E. Hull describes the microscopic structure of a granitoid quartz-porphyry from Galway, in which "the silica has consolidated into individual sub-crystalline grains before the other minerals, whereas in all true granites the silica has been the last to consolidate. The presence of aqueous (?) vapour during the consolidation of this rock is shown by the existence of numerous fluid cavities, and is another feature in which it resembles true granites."—Mr. G. W. Morehouse's paper on the structure of the scales of *Lepisma saccharina*, is reprinted from the *American Naturalist.*

Poggendorff's Annalen der Physik und Chemie, No. 8, 1873.—In this number, M. Riess criticises four different methods for determining the duration of discharge of a Leyden battery; that of Wheatstone, with rotating mirror; that of Lucas and Cazin, with rotating slitted disc; the electrical thermometer; and the electro-dynamometer. He shows, from experiments with the first two, that the light-duration of the spark consists of two time-parts; the discharge-time of the battery, and the duration of the after-glow of particles of metal present in the spark. These two parts vary, sometimes in the same direction, sometimes in opposite directions. Thus the duration of the discharge and the luminous duration of the discharge-spark stand in no fixed relation to each other.—In a paper on polarisation of electrodes in the voltaic arc, M. Herwig obtains results different from those of Grove on the same subject. His final mode of experiment was with a ball of pure silver as one electrode, and a plate of copper as the other; the ball being moved from point to point over the plate. Only the silver was here pulverised and any repeated action on what of it passed to the plate was prevented. M. Herwig found that the waste of silver was not even remotely equivalent to the quantity of hydrogen developed in the voltameter.—Dr. Rink has a paper on the velocity of sound, in which he raises some objections to the conclusion to which M. Regnault was led by experiments with the gas and water pipes of Paris, viz., that the velocity of sound is dependent on its intensity, and that a weak wave is propagated less quickly than a strong one.—A lengthy article by M. Riecke treats of the magnetisation of soft iron. He gives experimental determinations of the functions of magnetisation for different kinds of iron (by which is meant the induced magnetic moment divided by the magnetising force).—In a note on the relations between capillary and electric phenomena, M. G. Lippmann describes a capillary electrometer and an electro-capillary motor (with illustrations). In the latter, two bundles of fine glass tubes, dipping in separate vessels of mercury, are moved up and down alternately through the changes of form the mercury surface undergoes from polarisation with a galvanic current; and this motion is converted into rotary by a system of levers.—M. Bergh proposes an application of solar heat as a motor force,—vaporising sulphurous acid contained in vessels on the roof of a workshop. He would add to the solar machine, Natterer's apparatus for condensing carbonic acid; the force thus stored up might be used when solar heat was deficient.—M. Leyser describes a new form of Holtz's machine; and among the remaining subjects treated in this number are, heat relations and decompositions in solution of mixed salts in water (Winckelmann), absorption of heat by pulverised carbon (Vierordt), determination of the relation of specific heat to the velocity of cooling of certain gases(Kohlrausch).

SOCIETIES AND ACADEMIES

LONDON

Royal Society, Jan. 8.—"On the Brom-Iodides," by Dr. Maxwell Simpson, F.R.S., Professor of Chemistry, Queen's College, Cork.

"Contributions to the History of the Orcins.—No. IV. On the Iodo-derivatives of the Orcins," by Dr. John Stenhouse, F.R.S.

"A Memoir on the Transformation of Elliptic Functions," by Prof. Cayley, F.R.S.

"On Electro-torsion," by George Gore, F.R.S.

This communication contains an account of a new phenomenon, of rods and wires of iron becoming twisted whilst under the influence of electric currents; and a full description of the conditions under which it occurs, the necessary apparatus, and the methods of using it.

The phenomenon of torsion thus produced is not a microscopic one, but may be made to exceed in some cases a twist of a quarter of a circle, the end of a suitable index moving through a space of 80 centimetres (= 31 in.). It is always attended by emission of sound.

The torsions are produced by the combined influence of helical and axial electric currents, one current passing through a long copper-wire coil surrounding the bar or wire, and the other, in an axial direction, through the iron itself. The cause of them is the combined influence of magnetism in the ordinary longitudinal direction induced in the bar by the coil-current, and transverse magnetism induced in it by the axial one.

The torsions are remarkably symmetrical, and are as definitely related in direction to electric currents as magnetism itself. The chief law of them is—*A current flowing from a north to a south pole produces left-handed torsion, and a reverse one right-handed torsion, i.e.* in the direction of an ordinary screw. Although each current alone will produce its own magnetic effect, sound, and internal molecular movement, neither alone will twist the bar, unless the bar has been previously magnetised by the other. Successive coil-currents alone in opposite directions will not produce torsion, neither will successive and opposite axial ones.

Signs of electro-torsion were obtained with a bar of nickel, but not with wires of platinum, silver, copper, lead, tin, cadmium, zinc, magnesium, aluminium, brass, or German-silver, nor with a thick rod of zinc, or a cord of gutta-percha.

Zoological Society, Jan. 6.—Dr. A. Günther, F.R.S., vice-president, in the chair.—Dr. A. Leith Adams exhibited and made remarks on the horns of a feral race of *Capra hircus*, from the Old Head of Kinsale. The horns were very remarkable for their large size and very close resemblance to those of *Capra ægagrus*.—Mr. P. L. Sclater, F.R.S., read a synopsis on the species of the genus *Synallaxis*, of the family *Dendrocolaptidæ*. The specimens of this difficult group in nearly all the principal collections of Europe and America had been examined, and the existence of 58 species ascertained, beside three of which the types were not accessible, and which were considered to be doubtful.—Mr. George Busk, F.R.S., read a paper on a new British Polyzoon, proposed to be called *Hippuria egertoni*, after Sir Philip Egerton, who had discovered it growing upon the carapace of a specimen of *Gonoplax angulatus*, dredged up at Berehaven in the course of last summer.—Mr. Alfred Sanders read a series of notes on the myology of *Phrynosoma coronatum*.—A communication was read from Dr. J. E. Gray, F.R.S., containing a description of the Steppe-cat of Bokhara, which he proposed to designate *Chaus caudatus*.—Sir Victor Brooke, Bart., read a paper on Sclater's Muntjac and other species of the genus *Cervulus*. In pointing out the distinctions which characterise the three existing species, *Cervulus muntjac*, *C. sclateri*, and *C. reevesii*, the author showed *C. sclateri*, the species of most northern range, to be intermediate in specific characters and size between the two others. Sir Victor pointed out an advance in the specialisation of the tarsus of *Cervulus* not hitherto observed. In this genus the navicular, cuboid and second and third cuneiform bones were anchylosed together and formed one single bone, the first cuneiform being represented by a very small and separate bone.—A second paper by Sir Victor Brooke contained the description of a new species of deer from Persia, a pair of horns of which he had received from Major Jones, H.B.M. Consul at Tabreez in Persia, and which he proposed to call *Cervus mesopotamicus*.—Major H. H. Godwin Austin read a paper on some birds obtained by him in 1872-73 along the main water-shed of the Brahmaputra and Irrawaddy Rivers. Of these ten were considered as new to Science, viz.:—*Sitta Nagensis, Garrulax galbanus, G. albosuperciliaris, Trochalopteron cineraceum, T. virgatum, Actinodura waldeni, Layardia robiginosa, Prinia rufula, Cisticola munipurensis, Munia subundulata*.—Mr. Garrod made some remarks upon the morbid symptoms presented by the Indian rhinoceros that had lately died in the Society's Gardens, and upon certain points in its anatomy.—Mr. Edwin C. Reed communicated a paper on the Chilian species of the Coleopterous families *Cicindelidæ* and *Carabidæ*.

Royal Microscopical Society, Jan. 7.—Chas. Brooke, F.R.S., in the chair.—Mr. Chas. Stewart gave an interesting *résumé* of a paper contributed by Dr. H. D. Schmidt of New Orleans on the origin and development of red blood-corpuscles in the human embryo, and illustrated his remarks by black-board diagrams enlarged from a number of most beautifully executed drawings which accompanied the paper.—A discussion followed, in which Dr. Lawson, Dr. Matthews, Mr. Stewart, and the president took part.—A paper was also read by Mr. Alfred Sanders on the Zoosperms of crustacea and other invertebrata.—The secretary read a paper by the Rev. W. H. Dallinger, giving a description of his method of preparing drawings of microscopical objects for class illustration, &c.—Mr. Richards exhibited a new arrangement for a tank microscope for the examination of objects under water to a depth of eight inches; and some beautiful slides of diatoms were shown under the society's instruments sent up by Capt. John Perry of Liverpool, containing the following species, viz.:—*Aulacodiscus formosus, Aulacodiscus margaritaceus*, and *Auliscus racemosus*, all recent.

Society of Biblical Archæology, Jan. 6.—Dr. Birch, F.S.A., president, in the chair. The following papers were read:—"The Sallier Papyrus containing the Wars of Rameses Meriamun with the Khita," translated with Annotations by Prof. Lushington.—This well-known text was supplemented by a fragment from the Raifet Collection; it contains perhaps the most vivid picture of a pre-Homeric battle extant: the king himself, the chief actor, frequently speaking in the first person. The two finest passages, the prayer of Rameses to his father Amun, and the defeat of the Hittites, possessing peculiar beauty, in addition to the interest attaching itself to a people who, about 1,200 B.C. were formidable enemies to the Egyptians themselves.—"On some illustrations of the Book of Daniel from the Assyrian Inscriptions," by H. Fox Talbot, F.R.S.

MANCHESTER

Literary and Philosophical Society, Dec. 16, 1873.—"On the Destruction of Sound by Fog and the Inertness of a Heterogeneous Fluid," by Prof. Osborne Reynolds, M.A. The paper commences—That sound does not readily penetrate a fog is a matter of common observation. The bells and horns of ships are not heard so far during a fog as when the air is clear. In a London fog the noise of the wheels is much diminished, so that they seem to be at a distance when they are really close by. On one occasion during the launch of the *Great Eastern* the fog was reported so dense that the workmen could neither see nor *hear*. It has also been observed that mist in air or steam renders them very dull as regards motion. This is observed particularly in the pipes and passages in a steam engine. Mr. D. K. Clark found in his experiments that it required from 3 to 5 times as much back pressure to expel misty steam from a cylinder as when the steam was dry. The author then proceeds to explain these phenomena and to show that the particles of water do not, as it has sometimes been supposed, break up the waves of sound by small reflections in the same way as they scatter the waves of light, but that the destruction of sound is due, like the dulness of motion, to the fact that when foggy air is accelerated or retarded the drops of water move through the air and expend energy in fluid friction. He points out, as a well-known fact, that when foggy air is at rest under the action of gravity the drops of water are not at rest, but descend through the air with a velocity proportional to the square root of their diameters, and that consequently the energy destroyed in a given time is proportional to the square root of the diameters of the drops. He then shows that exactly the same is the case when the fog is subjected to a uniform acceleration and a somewhat similar effect when the acceleration is irregular or alternating. He says, This then fully explains the dulness with which foggy air acquires motion. In the passages of a steam engine the steam is subjected to continual accelerations and retardations each of which requires more force in the manner described with misty than with dry steam, and at each of which the particles of water moving through the steam destroy energy in creating eddies. Although not so obvious, the same is true in the case of sound. The effect of waves of sound traversing a portion of air is first to accelerate and then to retard it. And if there are any drops of water in the air these will not take up the motion of the air so readily as the air itself. They will allow the air to move backwards and forwards past them, and so cause friction and diminish the effect of the wave as it proceeds, just as a loose cargo will diminish the rolling of a ship. He then proceeds to examine the relation between the size of the drops and their effects, always supposing the same quantity of water to be present. He says—I do not know that it has ever been noticed whether a fine or a coarse mist produces the most effect on sound; it does not appear, however, that rain produces the same effect as fog, and considering rain as a coarse fog we must come to the conclusion that a certain degree of fineness is necessary. If we examine theoretically into the relation between the size of the drops and the effect they produce, always assuming the same quantity of water in the air, we find in the first place that if the air is subjected to a uniform acceleration, which acts for a sufficient time for the drops to acquire their maximum velocity through the air, the effect of the drops in a given time—that is to say, the energy dissipated in a given time—is proportional to the square root of the diameters of the drops. This appears from the action of gravity. As previously stated, the maximum downward motion of the drops, and hence the distance they will have fallen in a given time and the energy destroyed, is proportional to the square root of their diameters. Hence where the acceleration acts continuously for some time, as would be the case in a steam-pipe, the effect will increase with the size of the drops. This effect may be represented by a parabolic curve in which distances measured from the vertex along the axis represent the size of the drops and the corresponding ordinates represent their effect in destroying energy. If on the other hand the acceleration alternates very rapidly then there will not be time for the drop to acquire its maximum velocity, and if the time be very short the drop will practically stand still, in which case the effect of the drops will be proportional to the aggregate surface which they expose. And this will increase as the diameter diminishes, always supposing the same quantity of water to be present. This latter is somewhat the condition when a fog is traversed by waves of sound, so long as the drops are above a certain size; when, however, they are very small, compared with the length of the waves, there will be time for them to acquire their maximum velocity. So that starting from drops the size of rain, their effect will increase as their size diminishes, at first in the direct proportion, then more and more slowly until a certain minuteness is reached, after which, as the drops become still smaller, their effect will begin to diminish, at first slowly, but in an increasing ratio tending towards that of the square root of the diameter of the drops. This effect may be represented by a curve which coincides with the previously described parabola at the vertex, but which turns off towards the axis, which it finally approaches as a straight line. This completes the investigation so far as I have been able to carry it. The complete mathematical solution of the equations of motion does not appear to be possible, as they are of a form that has not as yet been integrated. However, so far it appears to me to afford a complete explanation of the two phenomena, and further to show, a fact not hitherto noticed, that for any note of waves of sound there is a certain size of drop with which a fog will produce the greatest effect.

EDINBURGH

Botanical Society, Jan. 8.—The following communications were read:—Obituary Notice of Dr. J. Lindsay Stewart, by Dr. Cleghorn.—Note on a Station for *Primula veris* in Coldingham Bay, Berwickshire, by Sir Robert Christison, Bart.—Notes of a visit to Messrs. Dickson and Turnbull's Nurseries, Perth, with remarks on arboricultural subjects, by James M'Nab, V.P.—Note on the destruction by frost of seedling ash trees in Mr. Robertson's nursery ground, near Fettes College, in May 1873, by Alexander Buchan, M.A.—Notice of botanical excursions in 1873, by Prof. Balfour.—Notes on some British fungi, by Prof. Dickson and Mr. John Sadler. Specimens were exhibited.

VICTORIA

Microscopical Society, Oct. 30, 1873.—Mr. W. H. Archer, the president, occupied the chair.—Mr. T. S. Ralph addressed the society relative to a fungus affecting the rye-grass, which has been brought before the notice of the society. He regarded its botanical position as uncertain, but was inclined to think it belonged to a lower form of fungus than *Clavaria*. In a specimen which he had prepared, the mycelium or network of the thread of the fungus would be observed penetrating the cells of the rye-grass, thus robbing the cells of the materials intended for the nourishment of the plant. These mycelial threads travelled through the cells, and ultimately coming to the surface of the leaf, produced the peculiarly reddish film which attracted the eye of the observer, besides the withering of the leaf of the plant.—Mr. F. Barnard exhibited some foraminifera, collected from various parts of the colony and in Queensland, some of which were unnamed and new to recent observers.—The President (Mr. Archer) brought forward living specimens of the polyp *Tyrcha viridis*, and of some freshwater polyzoa, the latter being apparently a new species, and allied to Fredericella, of which he had found species in a pool on the banks of the Yarra.

PARIS

Academy of Sciences, Jan. 5—M. Bertrand in the chair. This being the first meeting of the year the members proceeded to elect a vice-president. [See NOTES.] M. de Quatrefages, the retiring president, then read his report, after which the Academy proceeded with its usual business—the following papers were read.—On the conductibility of magnetic tensions, by M. Jamin.—On a new and simple form of the pro-embryo of echinoderms Stelleridæ (*Asteriscus verruculatus*), by M. H. de Lacaze-Duthiers. A mechanical interpretation of the laws of Dulong and Petit, and Wœstyn on specific atomic heats, by M. A. Ledieu. This paper contained a number of mathematical data in relation to the recent papers of MM. Lockyer, Dumas, and Berthelot.—Remarks on the relations between specific heats and atomic weights in simple and compound bodies, by M. A. Pissis. The author states that these relations tend to show that there is no distinction really existing between simple and compound bodies, but that on the contrary the so-called elements behave to a certain extent like binary compounds.—On ammoniacal urine, its dangers, and the means of preventing it, by MM. Gosselin and Robin. M. Pasteur observed in connection with this subject, that it would be of great importance to ascertain if this characteristic of urine is not connected with the presence of an organised ferment.—The perpetual secretary read a note from M. Poey on the connection between sun-spots, earthquakes in the Antilles and Mexico, and volcanic eruptions throughout the world.—Researches on the conditions under which a conoid of a given curve exhibits a contact of a determinate order, by M. Painvin.—An answer to M. Faye's remarks on terrestrial waterspouts, by M. Th. Reye. M. Faye made some remarks in reply.—On the variable period in the closing of a voltaic circuit, by M. A. Cazin. This was an answer to M. Blaserna's remarks.—On the conditions necessary for the formation of octahedral borax, by M. de Gernez.—On the geological conditions of the islands adjacent to the African shore from Morocco to Tunis.—On a Marine Carboniferous flora discovered in the neighbourhood of l'Ardoissière in the valley of Lichon (Forez).—On the geographical distribution of the ferns of New Caledonia, by M. Eng. Fournier.—On the pluvial law of the torrid zone, in the basin of the Atlantic Ocean, by M. V. Raulin.

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ERRATUM.—Vol. ix. p. 132, 1st col. line 19, for "Mr. J. D. Painter" read "Mr. J. D. Sainter."