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THURSDAY, OCTOBER 15, 1874

THE UNIVERSITIES COMMISSION REPORT

I.

THE publication of this Report has been awaited with an interest which rarely attends the issue of a Blue Book: and though the Commissioners have taken two years and a half over their labours, the result, both in its matter and its form, fully justifies their apparent delay. We have here presented to us in a concise and intelligible shape, the entire financial affairs of the Universities of Oxford and Cambridge with their Colleges. The whole property of these wealthy institutions, its sources and its application, the probability of its increase, and their annual income and expenditure, are now for the first time laid before the public.

It is in itself no small thing that these ancient corporations, with one single exception, should have been prevailed upon without direct Parliamentary pressure to reveal their most cherished secrets: for it should be remembered that only twenty years ago the first University Commission failed totally in its attempt to extract similar information from the unreformed Colleges, and that even up to the present time not even a University man had materials from which to form a reasonable conjecture as to the wealth of any other College than that of which he might happen to be a Fellow. It must be admitted that the Colleges come out from this ordeal of publicity with a better show than even their friends had anticipated. To produce the elaborate returns which the Commissioners required, an immense amount of additional labour has been thrown upon the College Bursars, who, as the Report bears witness, are not over-abundantly requited for the large amount of work they do as managers of landed estates and treasurers of the general accounts. The Master of Sidney Sussex College, Cambridge, who is also Bursar, has alone proved recalcitrant; but as to all the rest, it is pleasant to read the language in which the Commissioners express their gratitude for the ready assistance which they have received, and the spirit of marked courtesy with which they have been met. It had been generally anticipated that the system of managing estates through these amateur land-agents would not be proved to be economical, but the facts seem to have been unexpected even by the Commissioners, who report that the cost of management of the whole external income averages somewhat under 3*l.* per cent. They also state that they have no reason to believe that the condition of the estates let at rack rent is below the average, though probably less outlay is made than by private landlords who improve their properties. There is, however, a large quantity of land still let on the old system of beneficial leases, concerning which method of letting a clear description is given in the Report, and the agricultural condition of this land is confessedly bad; but this mode of tenure is universally condemned, and is in process of being rapidly extinguished.

With regard to the internal income and its expenditure, the Commissioners are unable, owing to the complicated and varying manner in which these accounts are kept, to arrive at any general conclusions, but they condemn in unhesitating terms the custom which appears to prevail everywhere at Cambridge, by which the payments of the undergraduates as caution money and tuition fees are made directly to the College tutor, who not unnaturally is induced to regard this arrangement as a private affair between himself and his pupil, so that in some cases information on this subject has been unwillingly given, and in some others altogether withheld. Some disapproval also is expressed of the general mode in which the College accounts are kept, which may be explained by the circumstance that they were never intended for publicity, and in many instances retain the old Latin nomenclature. It was only in a few cases that a correctly drawn balance-sheet was obtainable, and in some cases the accounts of Trust funds are not kept properly distinct, and the balances of such accounts seem to be occasionally borrowed for the general purposes of the College, and no interest allowed. It is further observed that there is no case of audit by a professional auditor. These criticisms, after all, are upon minor matters, but they have a certain importance as showing that the Commissioners have been both searching in their inquiries and fearless in their comments, and also because from the terms of their appointment they were not permitted to make any more general recommendations with regard to the wide question of the uses of academical endowments.

The real value of this Report of course lies in the long and elaborate array of figures which it gives, and in its impressive totals. A mine of reliable information is here afforded to University reformers and all those who are interested in the advancement of science, from which they may learn how vast is the wealth at their disposal, and from which they may securely draw materials for a comprehensive scheme. The total income of the Universities and Colleges in the year 1871, which is the year which the Commissioners have fixed upon for all their calculations, amounted to no less than three quarters of a million, and the number of undergraduates was about 3,500. Of this total, Oxford receives the larger share by more than 70,000*l.*, while the number of undergraduates is just equal. Another calculation gives the external income of Oxford (by which term the Commissioners intend the revenue from endowments) at 336,000*l.*, and the internal income of the Oxford Colleges, which is mainly derived from dues, fees, and profits of establishment, at 58,000*l.*, besides tuition fees at 30,000*l.*, whereas the sum of only 41,000*l.* is spent in scholarships, exhibitions, &c. These figures should be compared with those lately given to the public in the Fifth Report of the Royal Commission on Scientific Instruction, which dealt with such voluntary institutions as University and King's Colleges, London, and Owens College, and from such comparison the conclusion will inevitably be drawn that University education is capable of being made self-supporting, and that the University endowments can only be justified in so far as they encourage, not the teaching, but the advancement of learning and science.

This conclusion is also strongly supported by a more minute examination of the figures in this Report bearing on the income and expenditure of the several Colleges. It has long been well known that the educational utility of a College bears no relation to the value of its endowments, but this truth can now be enforced by very definite examples. King's College, Cambridge, has a revenue from endowment of 31,000*l.*, and has from 20 to 30 undergraduates; Exeter College, Oxford, has an endowment of less than 6,000*l.*, and educates 180 undergraduates, from whose payments a profit is derived which exceeds the external income by nearly 6,000*l.* A comparison also between Corpus Christi College, Oxford, where the sum of 975*l.* in the year is actually drawn from the endowments to pay the balance of the kitchen and buttery accounts, and Keble College, which has absolutely no endowment and yet exhibits a profit of 500*l.* on the year's account, equally teaches the lesson that out of tutorial and other fees, and fair boarding charges, an unendowed institution is capable of paying its own way, even in the face of competition with extravagant endowments. It appears, then, that by far the larger portion of the University endowments are not applied to educational purposes proper, nor apparently is it desirable that more should be devoted to that object, so that those are proved to be not far wrong who have urged that all this wealth is in the main wasted upon sinecures, and is readily available for the direct advancement of science and pure learning. At Oxford, the Heads of Houses and Fellows, more than two-thirds of whom are non-resident, receive yearly 131,000*l.*, and the remainder of the revenue is expended upon various minor charges which are probably inseparable from the possession of large landed estates and considerable buildings and grounds. It is then to this 131,000*l.* that the attention of reformers must be directed, and the question of its proper uses becomes the more important when it is added that the Commissioners anticipate that in the next fifteen years the Colleges will receive an increase, due to the falling in of beneficial leases, of 123,000*l.* It is probable, nay, almost certain, that this total will be considerably increased, partly by a general rise in the value of land, and partly through building leases, so that by the end of this century Oxford will have a yearly sum of 260,000*l.* upon which there is no present claim of more importance than those of Headships and Fellowships. If the revenues of Cambridge are treated according to the same principle of calculation, the amount paid to scholars and expended in general purposes being knocked off and the probable increase being included, the Colleges of that University will have at the same date about 160,000*l.*, so that Oxford will then appear even more than now the richer of the two. In our next article we shall point out how this large sum might be yet further increased, if the connection with the Church of England, which has always hampered to so great an extent the usefulness of the Colleges, were finally severed, and if all the academical endowments were to be strictly applied to academical purposes; but even without such severance a sufficient surplus is shown to induce the much-desired agreement as to its proper application, so that it may not continue to be wasted, nor diverted, as some have suggested, to the great towns; a mode of action which will induce all towns to do nothing in order that the Universities may eventually help them, and more than ever justify the French criticism that our Universities are nothing more than *Hautes Lycées*, instead of being, as they should be, the active centres of learning and research. It is to a Liberal Ministry that we owe the Commission which has yielded this valuable Report, but according to all appearances it will be a Conservative Government that must undertake the more important task of inaugurating the work of fundamental University Reform.

METEOROLOGICAL REFORM

WE would invite our readers' attention to an article which appears in this number of NATURE on the necessity for placing Physical Meteorology on a rational basis.

It forms the substance of a paper brought before the recent meeting of the British Association by Col. Strange, who has taken, as our readers well know, a very prominent part in the reconstruction of British Science, and to whom we are indebted for the present very earnest and lucidly argued protest in favour of a more rational way of treating meteorology.

He begins by dividing meteorology into two branches—one of these relating to weather and climate and their effects on organised life; while the other deals with the great physical motions of the atmosphere and with their causes.

To know beforehand the climatic peculiarities of a watering-place or country seat is no doubt of much importance, especially for an invalid who is in search of a healthy locality, but this does not constitute physical meteorology. It forms, we venture to think, a more important and certainly a more difficult branch of inquiry to study the earth's envelope as a whole, to ascertain the nature of the movements to which the moveable parts of it are subject, and finally to investigate the physical causes of these. It is in this latter aspect that the meteorology of the day is so lamentably deficient. The great fault in the present system has been well put by Col. Strange.

Two things have been taken for granted by meteorologists. In the first place, it has been imagined that the sun affects the earth in only one way, namely, by means of its radiation; and secondly, they appear to have taken for granted that this radiant influence is a constant quantity. So much indeed have these most important factors been overlooked, that we believe no systematic effort has yet been made to measure the sun's radiant influence, and indeed no proper instrument has yet been devised by which this can be done in a satisfactory manner. Without doubt the great question for meteorologists is that put by Col. Strange: "Is the sun a constant quantity?"

Now, if the evidence in favour of the sun's constancy were absolutely overwhelming, even then the present system would be at fault, inasmuch as no systematic attempts have been made to measure the strength of the solar influence: but how much more is the system deficient when it refuses to investigate an influence which is certainly predominant and most probably inconstant. To give our readers some idea of the evidence in favour of this latter assertion, let us quote the following words from a letter contained in a report presented to the British Association by a committee appointed to consider the question of scientific organisation:—

"Recent investigations have increased the probability of a physical connection between the condition of the sun's surface, and the meteorology and magnetism of our globe.

"In the first place, we have the observations of Sir E. Sabine, which seem to indicate a connection between sun-spots and magnetic disturbances, inasmuch as both phenomena are periodical, and have their maxima and minima at the same times.

"On the other hand, the researches of Messrs. Baxendell and Meldrum appear to indicate a relation between the wind-currents of the earth and its magnetism, and also between the earth's wind-currents and the state of the sun's surface.

"In the last place, the researches of Messrs. De la Rue, Stewart, and Loewy appear to indicate a connection between the behaviour of sun-spots and the positions of the more prominent planets of our system. Whatever be the probability of the conclusions derived from these various researches, they at least show the wisdom of studying together for the future these various branches of observational science."

A further report by the same committee tells us that "It is not enough to obtain a record of the areas and positions of the various sun-spots. The velocity of cyclonic motion, the chemical nature of the outbursts, the disposition and character of the faculæ and prominences, and many other points, are, as shown by Mr. Lockyer, even more characteristic of the nature of solar action than the magnitude of the spotted area, and are equally worthy of a careful and constant study."

The evidence in favour of some strange and variable action of the sun may, perhaps, be compared to that in favour of the existence of America before that continent was discovered by Columbus; and it might have been thought that in an age like the present the difficulty of organising solar research would be very much less than that experienced by Columbus in organising an American expedition; but this is not the case. Indeed, it is not very creditable to the scientific authorities of this country that they have not entered more readily into a subject of this importance. From the quotations given above, our readers will see that this is not the first time the subject has been brought before the British Association.

A large and influential committee, embracing in its ranks many of the most distinguished members of the Association, endeavoured to bring the subject before the Administrative Council of that body, but did not succeed in getting the Council to move in the matter, or even to pronounce any opinion upon the subject. We hardly think this was proper treatment of an important problem, which had found such advocates as Col. Strange, Drs. De la Rue and Joule, Messrs. Baxendell, Lockyer, and Meldrum, as well as the general support of the most distinguished physicists of the country.

Clearly Col. Strange is right in supposing that a problem of this importance and extent can be properly undertaken only by Government. His remarks on this subject are so well put that we will report them here. Starting with the fundamental axiom that private enterprise should be allowed the most perfect freedom from interference or competition by the State, he lays down the following conditions for Government action in any scientific problem:—

(*a*) That the probable results of the research be beneficial, in the widest sense of that term, to the community at large, or to the various departments of the State.

(*b*) That the research is too costly or commercially too unremunerative to be undertaken and vigorously prosecuted by individuals.

(*c*) That the research requires continuous, uninterrupted work, extending over very long periods, and conducted by systematically organised establishments.

It will at once be seen that all these conditions apply to solar research; and the Governments of other nations have already perceived the fact. Our readers are aware that the Governments of France and America have it in contemplation to establish solar observatories, and a recent number of this periodical informs them that the German Government has already founded one on a large scale, of which it is possible the illustrious Kirchhoff will be the Director.

In conclusion, as we are advocating a question of reform, it is desirable that something in the shape of practical suggestions should be made. Now, in the first place and with reference to the great problem of Solar Physics, we think that this should certainly be encouraged by the establishment of a distinct central observatory devoted to the purpose; for it would be manifestly unfair to our illustrious Astronomer Royal to throw upon him the additional burden of an institution so very different from that over which he now presides.

In the next place, with reference to photographical delineations of the solar disc, Col. Strange has made a suggestion, at once so practical and simple, that we cannot do better than quote his own words:—

"With respect to sun-spot researches, it fortunately happens that the photographic records need not be all taken at the same station. The record of one day taken in England can be combined with the record of the next day taken at the other side of the globe. Hence, in order to obtain this daily record it is only necessary to select a certain number of stations in localities such that there shall always be clear weather at one of them. India offers peculiar facilities for such a selection of stations, owing to the great variety of climate to be found in that country during the same period of the year. Perhaps four or five such stations would suffice for India, and if absolute continuity of record could not be obtained by them, the deficiencies could easily be made good by stations in our colonial possessions."

It is well known how slowly such things march in this country; nevertheless we look with much confidence to the forthcoming report of the Royal Commission appointed to investigate matters of this nature, and to urge upon Government such means as they consider shall tend to the advancement of science and to the good of the country.

BALFOUR STEWART

VAN DER WAALS ON THE CONTINUITY OF THE GASEOUS AND LIQUID STATES

Over de continuiteit van den gas- en vloeistoftoestand. Academisch proefschrift. Door Johannes Diderik van der Waals. (Leiden: A. W. Sijthoff, 1873.)

THAT the same substance at the same temperature and pressure can exist in two very different states, as a liquid and as a gas, is a fact of the highest scientific importance, for it is only by the careful study of the difference between these two states, the conditions of the substance passing from one to the other, and the phenomena which occur at the surface which separates a liquid from its vapour, that we can expect to obtain a dynamical theory of liquids. A dynamical theory of "perfect" gases is already in existence; that is to say, we can explain many of the physical properties of bodies when in an extremely rarefied state by supposing their molecules to be in rapid motion, and that they act on one another only when they come very near one another. A molecule of a gas, according to this theory, exists in two very different states during alternate intervals of time. During its encounter with another molecule, an intense force is acting between the two molecules, and producing changes in the motion of both. During the time of describing its free path, the molecule is at such a distance from other molecules that no sensible force acts between them, and the centre of mass of the molecule is therefore moving with constant velocity and in a straight line.

If we define as a perfect gas a system of molecules so sparsely scattered that the aggregate of the time which a molecule spends in its encounters with other molecules is exceedingly small compared with the aggregate of the time which it spends in describing its free paths, it is not difficult to work out the dynamical theory of such a system. For in this case the vast majority of the molecules at any given instant are describing their free paths, and only a small fraction of them are in the act of encountering each other. We know that during an encounter action and reaction are equal and opposite, and we assume, with Clausius, that on an average of a large number of encounters the proportion in which the kinetic energy of a molecule is divided between motion of translation of its centre of mass and motions of its parts relative to this point approaches some definite value. This amount of knowledge is by no means sufficient as a foundation for a complete dynamical theory of what takes place during each encounter, but it enables us to establish certain relations between the changes of velocity of two molecules before and after their encounter.

While a molecule is describing its free path, its centre of mass is moving with constant velocity in a straight line. The motions of parts of the molecule relative to the centre of mass depend, when it is describing its free path, only on the forces acting between these parts, and not on the forces acting between them and other molecules which come into play during an encounter. Hence the theory of the motion of a system of molecules is very much simplified if we suppose the space within which the molecules are free to move to be so large that the number of molecules which at any instant are in the act of encountering other molecules is exceedingly small compared with the number of molecules which are describing their free paths. The dynamical theory of such a system is in complete agreement with the observed properties of gases when in an extremely rare condition.

But if the space occupied by a given quantity of gas is diminished more and more, the lengths of the free paths of its molecules will also be diminished, and the number of molecules which are in the act of encounter will bear a larger proportion to the number of those which are describing free paths, till at length the properties of the substance will be determined far more by the nature of the mutual action between the encountering molecules than by the nature of the motion of a molecule when describing its free path. And we actually find that the properties of the substance become very different after it has reached a certain degree of condensation. In the rarefied state its properties may be defined with considerable accuracy in terms of the laws of Boyle, Charles, Gay-Lussac, Dulong and Petit, &c., commonly called the "gaseous laws." In the condensed state the properties of the substance are entirely different, and no mode of stating these properties has yet been discovered having a simplicity and a generality at all approaching to that of the "gaseous laws." According to the dynamical theory this is to be expected, because in the condensed state the properties of the substance depend on the mutual action of molecules when engaged in close encounter, and this is determined by the particular constitution of the encountering molecules. We cannot therefore extend the dynamical theory from the rarer to the denser state of substances without at the same time obtaining some definite conception of the nature of the action between molecules when they are so closely packed that each molecule is at every instant so near to several others that forces of great intensity are acting between them.

The experimental data for the study of the mutual action of molecules are principally of two kinds. In the first place we have the experiments of Regnault and others on the relation between the density, temperature, and pressure of various gases. The field of research has been recently greatly enlarged by Dr. Andrews in his exploration of the properties of carbonic acid at very high pressures. Experiments of this kind, combined with experiments on specific heat, on the latent heat of expansion, or on the thermometric effect on gases passing through porous plugs, furnish us with the complete theory of the substance, so far as pure thermodynamics can carry us.

For the further study of molecular action we require experiments on the rate of diffusion. There are three kinds of diffusion—that of matter, that of visible motion, and that of heat. The inter-diffusion of gases of different kinds, and the viscosity and thermal conductivity of a gaseous medium, pure or mixed, enable us to estimate the amount of deviation which each molecule experiences on account of its encounter with other molecules.

M. Van der Waals, in entering on this very difficult inquiry, has shown his appreciation of its importance in the present state of science; many of his inves igations are conducted in an extremely original and clear manner; and he is continually throwing out new and suggestive ideas; so that there can be no doubt that his name will soon be among the foremost in molecular science.

He does not, however, seem to be equally familiar, as yet, with all parts of the subject, so that in some places, where he has borrowed results from Clausius and others, he has applied them in a manner which appears to me erroneous.

He begins with the very remarkable theorem of Clausius, that in stationary motion the mean kinetic energy of the system is equal to the mean virial. As in this country the importance of this theorem seems hardly to be appreciated, it may be as well to explain it a little more fully.

When the motion of a material system is such that the sum of the moments of inertia of the system about three axes at right angles to each other through its centre of mass does not vary by more than small quantities from a constant value, the system is said to be in a state of stationary motion. The motion of the solar system satisfies this condition, and so does the motion of the molecules of a gas contained in a vessel.

The kinetic energy of a particle is half the product of its mass into the square of its velocity, and the kinetic energy of a system is the sum of the kinetic energy of its parts.

When an attraction or repulsion exists between two points, half the product of this stress into the distance between the two points is called the Virial of the stress, and is reckoned positive when the stress is an attraction, and negative when it is a repulsion. The virial of a system is the sum of the virial of the stresses which exist in it.

If the system is subjected to the external stress of the pressure of the sides of a vessel in which it is contained, the amount of virial due to this external stress is three halves of the product of the pressure into the volume of the vessel.

The virial due to internal stresses must be added to this.

The theorem of Clausius may now be written—

$$\frac{1}{2}\Sigma(m\overline{v^2}) = \frac{3}{2}pV + \frac{1}{2}\Sigma\Sigma(Rr)$$

The left-hand member denotes the kinetic energy.

On the right hand, in the first term, p is the external pressure on unit of area, and V is the volume of the vessel.

The second term represents the virial arising from the action between every pair of particles, whether belonging to different molecules or to the same molecule. R is the attraction between the particles, and r is the distance between them. The double symbol of summation is used because every pair of points must be taken into account, those between which there is no stress contributing, of course, nothing to the virial.

As an example of the generality of this theorem, we may mention that in any framed structure consisting of struts and ties, the sum of the products of the pressure in each strut into its length, exceeds the sum of the products of the tension of each tie into its length, by the product of the weight of the whole structure into the height of its centre of gravity above the foundations. (See a paper on "Reciprocal Figures, &c." Trans. R. S. Edin., vol. xxvi. p. 14. 1870.)

In gases the virial is very small compared with the kinetic energy. Hence, if the kinetic energy is constant, the product of the pressure and the volume remains constant. This is the case for a gas at constant temperature. Hence we might be justified in conjecturing that the temperature of any one gas is determined by the kinetic energy of unit of mass.

The theory of the exchange of the energy of agitation from one body to another is one of the most difficult parts of molecular science. If it were fully understood, the physical theory of temperature would be perfect. At present we know the conditions of thermal equilibrium only in the case of gases in which encounters take place between only a pair of molecules at once. In this case the condition of thermal equilibrium is that the mean kinetic energy due to the agitation of the centre of mass of a molecule is the same, whatever be the mass of the molecule, the mean velocity being consequently less for the more massive molecules.

With respect to substances of more complicated constitution, we know, as yet, nothing of the physical condition on which their temperature depends, though the researches of Boltzmann on this subject are likely to result in some valuable discoveries.

M. Van der Waals seems, therefore, to be somewhat too hasty in assuming that the temperature of a substance is in every case measured by the energy of agitation of its individual molecules, though this is undoubtedly the case with substances in the gaseous state.

Assuming, however, for the present that the temperature is measured by the mean kinetic energy of a molecule, we obtain the means of determining the virial by observing the deviation of the product of the pressure and volume from the constant value given by Boyle's law.

It appears by Dr. Andrews' experiments that when the volume of carbonic acid is diminished, the temperature remaining constant, the product of the volume and pressure at first diminishes, the rate of diminution becoming more and more rapid as the density increases. Now, the virial depends on the number of pairs of molecules which are at a given instant acting on one another, and this number in unit of volume is proportional to the square of the density. Hence the part of the pressure depending on the virial increases as the square of the density, and since, in the case of carbonic acid, it diminishes the pressure, it must be of the positive sign, that is, it must arise from *attraction* between the molecules.

But if the volume is still further diminished, at a certain point liquefaction begins, and from this point till the gas is all liquefied no increase of pressure takes place. As soon, however, as the whole substance is in the liquid condition, any further diminution of volume produces a great rise of pressure, so that the product of pressure and volume increases rapidly. This indicates negative virial, and shows that the molecules are now acting on each other by *repulsion*.

This is what takes place in carbonic acid below the temperature of 30·92° C. Above that temperature there is first a positive and then a negative virial, but no sudden liquefaction.

Similar phenomena occur in all the liquefiable gases. In other gases we are able to trace the existence of attractive force at ordinary pressures, though the compression has not yet been carried so far as to show any repulsive force. In hydrogen the repulsive force seems to prevail even at ordinary pressures. This gas has never been liquefied, and it is probable that it never will be liquefied, as the attractive force is so weak.

We have thus evidence that the molecules of gases attract each other at a certain small distance, but when they are brought still nearer they repel each other. This is quite in accordance with Boscovich's theory of atoms as massive centres of force, the force being a function of the distance, and changing from attractive to repulsive, and back again several times, as the distance diminishes. If we suppose that when the force begins to be repulsive it increases very rapidly as the distance diminishes, so as to become enormous if the distance is less by a very small quantity than that at which the force first begins to be repulsive, the phenomena will be precisely the same as those of smooth elastic spheres.

M. Van der Waals makes his molecules elastic spheres, which, when not in contact, attract each other. His treatment of the "molecular pressure" arising from their attraction seems ingenious, and on the whole satisfactory, though he has not attempted a complete calculation of the attractive virial in terms of the law of force.

His treatment of the repulsive virial, however, shows a departure from the principles on which his investigation is founded. He considers the effect of the size of the molecules in diminishing the length of their "free paths," and he shows that this effect, in the case of very rare gases, is the same as if the volume of the space in which the molecules are free to move had been diminished by four times the sum of the volumes of the molecules themselves. He then substitutes for V, the volume of the vessel in Clausius' formula, this volume diminished by four times the molecular volume, and thus obtains the equation—

$$\left(p + \frac{a}{V^2}\right)(V - b) = R(1 + at),$$

where p is the externally applied pressure, $\frac{a}{V^2}$ is the molecular pressure arising from attraction between the molecules, which varies as the square of the density, or inversely as the square of the volume. The first factor is thus what he considers the total effective pressure. V is the volume of the vessel, and b is four times the volume of the molecules. The second factor is therefore the "effective volume" within which the molecules are free to move.

The right hand member expresses the kinetic energy, represented by the absolute temperature, multiplied by a quantity, R, constant for each gas.

The results obtained by M. Van der Waals by a comparison of this equation with the determinations of Regnault and Andrews are very striking, and would almost persuade us that the equation represents the true state of the case. But though this agreement would be strong evidence in favour of the accuracy of an empirical formula devised to represent the experimental results, the equation of M. Van der Waals, professing as it does to be derived from the dynamical theory, must be subjected to a much more severe criticism.

It appears to me that the equation does not agree with the theorem of Clausius on which it is founded.

In that theorem p is the pressure of the sides of the vessel, and V is the volume of the vessel. Neither of these quantities is subject to correction.

The assumption that the kinetic energy is determined by the temperature is true for perfect gases, and we have no evidence that any other law holds for gases, even near their liquefying point.

The only source of deviation from Boyle's law is therefore to be looked for in the term $\frac{1}{2}\Sigma\Sigma(Rr)$, which expresses the virial. The effect of the repulsion of the molecules, causing them to act like elastic spheres, is therefore to be found by calculating the virial of this repulsion.

Neglecting the effect of attraction, I find that the effect of the impulsive repulsion reduces the equation of Clausius to the form—

$$pV = \frac{1}{3}\Sigma(mv^2)\left\{1 - 2\log.\left(1 - 8\frac{\rho}{\sigma} + 17\frac{\rho^2}{\sigma^2} - \&c.\right)\right\}$$

where σ is the density of the molecules and ρ the mean density of the medium.

The form of this equation is quite different from that of M. Van der Waals, though it indicates the effect of the impulsive force in increasing the pressure. It takes no account of the attractive force, a full discussion of which would carry us into considerable difficulties.

At a constant temperature the effect of the attractive virial is to diminish the pressure by a quantity varying as the square of the density, as long as the encounters of the molecules are, on the whole, between two at a time, and not between three or more. The effect of the attraction in deflecting the paths of the molecules is to make the number of molecules which at any given instant are at distances between r and $r + dr$ of each other greater than the number in an equal volume at a greater distance in the proportion of the velocities corresponding to these distances. As the temperature rises, the volume being constant, the ratio of these velocities approaches to unity, so that the distribution of molecules according to distance becomes more uniform, and the virial is thus diminished.

If there is a virial arising from repulsive forces acting through a finite distance, a rise of temperature will increase the amount of this kind of virial.

Hence a rise of temperature at constant volume will produce a greater increase of pressure than that given by the law of Charles.

The isothermal lines at higher temperatures will exhibit less of the diminution of pressure due to attraction, and as the density increases will show more of the increase of pressure due to repulsion.

I must not, however, while taking exception to part of the work of M. Van der Waals, forget to add that to him alone are due the suggestions which led me to examine the theory of virial more carefully in order to explore the continuity of the liquid and the gaseous states.

I cannot now enter into the comparison of his theoretical results with the experiments of Andrews, but I would call attention to the able manner in which he expounds the theory of capillarity, and to the remarkable phenomenon of the surface tension of gases which he tells (p. 38) has been observed by Bosscha in tobacco smoke. As tobacco smoke is simply warm air with a slight excess of carbonic acid, carrying solid particles along with it, the change of properties at the surface of the cloud must be very slight compared with that at the surface where two really different gases first come together. If, therefore, the phenomenon observed by Bosscha is a true instance of surface-tension, we may expect to discover much more striking phenomena at the meeting-place of different gases, if we can make our observations before the surface of discontinuity has been obliterated by the inter-diffusion of the gases.

J. CLERK-MAXWELL

LETTERS TO THE EDITOR

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

An Anagram

THE practice of enclosing discoveries in sealed packets and sending them to Academies, seems so inferior to the old one of

Huyghens, that the following is sent you for publication in the old conservated form:—

$A^8C^3DE^{12}F^4GH^6I^6L^3M^3N^5O^6P$
$R^4S^5T^{14}U^6V^2WXY^2$

I WEST

"Manufactured Articles"

THERE are precedents to justify a hope that it would be no excursion beyond the province of NATURE, if somebody who knows that molecules possess the essential character of a manufactured article were kindly to explain how he knows a manufactured article when he sees it, in his mind's eye or elsewhere.

The answer used to be "contrivance, design; an end, a purpose; means for the end, adaptation to the purpose." This, it was said, we find in a watch; "we perceive that its several parts are framed and put together for a purpose." The same thing, it was further said, we find still more in the works of nature, "and that in a degree which exceeds all computation." And why so much more? Because "the contrivances of nature surpass the contrivances of art, in the complexity, subtlety, and curiosity of the mechanism; and still more, if possible, do they go beyond them in number and variety." This was the old answer: the new one is contained in such phrases as these: "exact equality," "exact unison," "exactly the same magnitude," "constants not approximately but absolutely identical."

Here it is hard not to stop and ask what can possibly prove that these things are absolutely so: or what can possibly contribute the smallest probability to a hypothesis that anything is absolutely anything, I do not say among the laws of nature, but among its collocations. Very likely it might be proved that the mean-square variation in the value of one of the above-mentioned constants is a prodigiously smaller fraction of its mean value than any other fraction which the molecular theory has occasion to take account of; and anyhow the fact remains that a molecule of bismuth, for instance, differs from a molecule of lead immensely more than two molecules of either can differ from one another. Perhaps this will do as well for the argument; if so, there is no excuse for the absolute; and whether or no, the argument will be the better for explanation, or perhaps it will be the worse for the argument.

However this may be, the difference between the old answer and the new one is rather instructive. An eager disputant might say the new one was contradictory of the old one; but it is safer to say that the new is at best independent of the old. Clearly a watch is about the last thing which would be cited to illustrate the new sort of manufactured article. The examples which our authors do by preference cite are coins, weights, and measures; and certainly it would be difficult to name manufactured articles which should better exemplify uniformity for the sake of uniformity. And for a very good reason (that is the worst of it); because the purposes of coins, weights, and measures are defeated, they who handle them deceived, and (as our authors are careful to say) they who manufacture them deceivers, so far as the things are not uniform. So the inference from such things only comes to this, that uniformity is a character of manufactured articles when uniformity is part of the purpose of manufacture. Is then the new argument, after all, a special case of the old one? Not so: for when men produce as a novelty a special case of an old argument, this must be because it is an especially strong case of the same; but we have seen that the old argument owes much of its virtue to complexity and variety; therefore, our modern manufactured articles, which are above all things simple and uniform, will only furnish a special case of the old argument by furnishing an especially weak one. Design, in short, has nothing to do with the new argument, and we must look for analogies among manufactured articles which are uniform, not because uniformity adapts them to their purpose, but simply because they *are* manufactured articles.

The nearest approach I can think of is to be found on a scale almost molecular, for number and sometimes for magnitude, in a London wilderness of similar and similarly situated houses. It is oppressive to walk past these boxes so nearly identical in form, and to think of the infinite variety of their contents; to think how different they would have been, and how much fitter for their purposes, if their inhabitants could have secreted them as a snail secretes his shell. And why does it make all the difference that they have been manufactured? Why did not the manufacturer vary them according to the interests connected with them? Of course because he did not care about those interests; because he could not foresee them; and because it would not answer to try and provide for them. And now we understand the sort of manufacturer the new argument reveals: a manufacturer who does not care what becomes of his articles the moment he gets them off his hands by his formulas beginning to be interpretable; a manufacturer who cannot solve his own equations except in a grossly approximative fashion; a manufacturer who could not give his constants the proper values if he knew what values to give them.

Uniformity, in short, is not as such the sign of a manufactured article, except as it may be the sign of an imperfect manufacturer. I do not suppose this is what the new argument is meant to mean: but this, I submit, is what it does mean. Perhaps, however, some competent supporter of it will kindly explain it a little.

C. J. MONRO

Yorkshire College of Science

WILL you permit a few words upon your allusion to this College in a leading article of the 8th inst.?

If its promoters have confined their present efforts to the establishment of a Faculty of Science, one cause has been that the amount of their funds compelled a selection instead of a comprehension of subjects. With a capital of 26,000*l*. they could not venture to cover so large a field as Owens College commenced upon with an invested endowment of four times the amount. But already, before our doors are opened, we have cheering signs that in providing a function to which endowments may be entrusted, the College will accrete to itself aid from widely-divergent quarters. The Royal assent has been given to an amended scheme of the Endowed Schools Commissioners for the Akroyd Charity, by which an important annual residue is allotted to the College, with representation upon the Trust. By the liberality of the Clothworkers' Company, the sum of 500*l*. per annum is set apart for three years for a Professor of Textile Industries and for Scholarships. Is it unreasonable to hope that new professorships will be established by the generosity of private individuals? The existence here of a flourishing School of Medicine is favourable to your views of massing the Faculties, and already a first link of union is being forged between the two bodies in relation to the classes in Chemistry.

Do not suppose that the College adopts *Pannus mihi panis* as its motto. A thoroughly practical community must run a risk of magnifying the *practice* of science rather than its *theory*, but if the selection of professors has been fortunate, there is no doubt that students will be taught practice through theory. Your forcible remarks will doubtless strengthen the hands of certain liberal donors to the College, who have offered increased sums when an Arts Faculty can be established.

Leeds, Oct. 12

R. REYNOLDS

On the Process of Tone-making in Organ-pipes

THE natural order of harmonic progression in an open organ-pipe is well known. That there is from the same pipe an inverse order of harmonics equally natural is not equally well known. There is no intimation that I am aware of, in any treatise on sound, of this fact having been observed, and the absence of recognition is no doubt attributable to a general disregard of the study of the comparative acoustics of musical instruments. My investigations into the process of tone-making in organ-pipes and other instruments have clearly shown me that there is *an order of transitive* harmonics distinct from the *order of concomitant* harmonics or "over-tones." Why I call them "transitive" will be apparent in the argument. Certain it is that our mimaphonic power in organ-pipes and in other musical devices depends on the command we can ensure over these two orders distinctively, and also on their comparative influences on the tones produced. In this manifestation of an inversion of harmonic progression, the nature, and, without extravagance one may say, the individuality, of the aeroplastic reed is most fully pronounced. Experimental proof is easily obtained, and, whilst bringing into prominence the peculiar display, will at the same time furnish indubitable evidence of the formative power exercised by the air-reed in the process of tone-making.

By the term "tone-making" is to be understood the manner of origination not merely of a note of defined pitch emitted by a musical instrument, but also of all the constituent sounds which give colour or quality to the note, and enter into the effect perceived by the ear. The artist, according to his sagacity, seizes on the faintest hints of nature, and with more or less consciousness of insight into law is able to control the process.

The modern theory of musical quality, or *timbre*, for which we are indebted primarily to Johannes Müller, and subsequently to Helmholtz, who by elaborate investigation has made the subject specially his own, takes account only of the varying intensities of the harmonics present in the compound tone, classed in two series, the "open" and the "stopped," or otherwise the "even" and "uneven," in regular progression. To the system of associated sounds in harmony the present inquiry has no reference; my purpose is to press the claim for recognition of another series in addition to these, to show that quality, and especially mimaphonic quality, in sounds, in whatever degree attributable to harmonics combined with the fundamental, is no less dependent for its character on the "order" in which harmonics come on or develop themselves in the growth of the tone. In plants there is a direct order of appearance—leaves, then flowers; a reversed order is as natural, and flowers come before leaves.

If an "open diapason" pipe of small scale is taken, and some slight variation made in the voicing, the pipe may be converted into a "flute harmonique," and it will give a note an octave higher than before; that is to say, the fundamental is abolished, and the octave or first harmonic reigns in its stead. The pipe will probably be now "unsteady," frequently attempting to reinstate the fundamental. This tendency we may counteract by drilling a small pin-hole at the side of the pipe, and the trifling amount of external air thereby admitted will destroy the tendency, by preventing the perfect formation of the node required by the fundamental. The perforation should be made at the true point of localisation of the node, which (as explained in a former letter in NATURE, vol. ix., p. 301) is at about $\frac{3}{7}$ of the whole length of pipe reckoned from the level of the mouth. If we next enlarge the hole at the foot of the pipe, thus allowing greater force to the wind-current, and if we have properly manipulated the pipe, we shall on the trial of its sound hear the twelfth coming on as the forerunner of the octave, most distinctly and with a perceptible interval between the appearance of the twelfth and octave. The effect is more certain if the mouth is cut to a height less than that marked by scale, which would be $\frac{1}{3}$ of the width of mouth; and if, further, the pipe is slightly coned—a provision favouring the harmonic. By other changes of treatment, the fifteenth or double octave may be brought out as the introductory harmonic, and the twelfth following, and if we will we may restore the original ground-tone. The "flute harmonique" in this style is to be chosen for this experiment, not as representative of quality, but that in this overstrained condition it clearly defines the entrance of each harmonic, the order of succession, and the interval between each. In other varieties of pipe the "quality" is characterised by these harmonics, and in this order, but so blended as it were in a "portamento" glide that even critical ears fail to detect the elements combined into the effect. It is, so to speak, "an excess" of nature, which is often necessary to open our eyes to the perception of her commonest realities.

A diapason pipe is never so strong and brilliant in character as when it is just verging on the transmutation of fundamental to octave; for good vigorous quality, therefore, it is restrained only to just within the limit; nevertheless the presence of the octave-harmonic as the precursor of the fundamental should always be felt with its jubilant energy, then afterwards, the fundamental taking full possession of the pipe, producing its own octave-harmonic with almost equal exuberance of power. The precursory harmonic is of the transitive order. We have to recognise two distinct series of open harmonics—the direct order, *over-tones of the pipe*, which are derivatives of the fundamental, and the inverse order, the tones of which may be called *stem-tones of the reed*, for they are thrown off by the reed in swift succession, and declare the non-isochronous nature of the air-reed's motion. There is nothing erratic about these stemnal harmonics or the order of their appearance; they are due to the untamed vigour of the reed, and have this distinguishing law—they are transitive, each one dies in giving birth to the next, whereas the over-tones of the pipe coexist with the fundamental, and are the direct consequence of the excess of excitation in the air-column of the pipe (see more at length in NATURE vol. viii., p. 383), providing a safety-valve for the permanence of pitch in the ground-tone, by employing the surplus energy acquired from the reed's vivacity in new forms of growth.

Whenever from an organ-pipe we hear harmonics together with the fundamental, then the air-reed is vibrating to its fullest amplitude, for it is the superabundant vitality of the air-column that sustains the coexistent ones; but when we hear harmonics independent of the fundamental, then we may be sure that they are the expression of the higher activity of the reed itself, then working with lessened *amplitude* of motion, yet with greater *velocity* of vibration.

The genesis of these tones is due to the association of reed and pipe. Without the pipe the reed could not produce tone, would be barren as one sex. As the pipe is silent and requires some external impulses to bring it into life, so the air-reed needs something to act upon before it can vibrate or swerve from its course in minute degree; some inequality of environment is all it asks—some alliance with power distinct from its own. Take away the pipe, leave it only the mouth, and it will pull against that and begin to work according to its nature, and even in that rudimentary condition will elicit tone of definite pitch.

Many classes of organ-pipes give harmonics of the direct order without a trace of those of the inverse order; on the other hand, the several varieties of pipes which give the inverse order invariably yield the direct order subsequently with the ground tone; and why? It will be comprehended at once, if I have rendered my meaning clearly, that the initial harmonics proclaim the intense vigour of the reed, and that force, unabated in strength, although widened in scope, is transferred to the air-column of the pipes The difference of effects produced by the two orders constitute. that variety of quality which distinguishes string-tone from horn-tone, and a further modification chiefly in relative times of sequence asserts its peculiarity as reed-tone; yet, again, there are in both series departures from truth of pitch, in some qualities an over-flatness of one or more harmonics, and in some an over-sharpness. The blast of the trumpet combines both flat and sharp harmonics strongly. The *direct* order of harmonics may be likened to an ascending arpeggio coalescing into a chord—the *transitive* to a descending arpeggio, in some instances having intervals regularly defined, in others starting abruptly and with wayward intensity, and in other displays passing swiftly onward to the fulness of tone, imperceptibly blended as is the "portamento" glide of voice or string.

In all the "Geigens" and "Gambas" and similar organ-pipes mimaphonic of "stringy quality," the transitive harmonics are the true cause of their speciality. Numerous experiments prove this to the eye as well as to the ear. I shall be able to show that the "Gambas" are characterised also by an over-sharpness of these transitive harmonics, and this paper is a necessary introduction to my proposed examination of the mode in which the peculiar quality of tone is built up in this attractive class of pipes.

HERMANN SMITH

Can Land-Crabs Live under Water?

PERMIT me to inform Mr. J. C. Galton that the authority for my statement in the "Outlines of Physiology" is also derived from "some book or other;" and that this "turns out" to be the classical "Hist. Nat. des Crustacés" of Milne-Edwards, vol. ii. pp. 16, 18, with which perhaps your correspondent is unacquainted.

Milne-Edwards, in his turn, refers (p. 19) to those who have studied the land-crabs in the Antilles and on the South American coast, viz., Rochefort, Feuillée, Labat, and Brown. He elsewhere, also, treats the subject as a comparative anatomist and physiologist (Ann. des Sciences Nat.; Todd's "Cyclopædia").

Whether the land-crabs of the east differ in their habits from those of the west is of course open to inquiry; and also in what ways (either anatomically or physiologically) they differ; but the question is clearly not whether they can survive for a few hours under water, but whether practically they can live in that element or are at last asphyxiated in it.

10, Savile Row, Oct. 6 JOHN MARSHALL

Bright Meteors

AT 8.55 this evening a party of six observed a meteor in the constellation Aries, or below it, which emitted light sufficient to cast a bright gleam on the neighbouring trees. The body of the meteor shot rapidly along a course extending about 20°. It then seemed to explode suddenly, and its track was luminous for a short time. The granular *débris* of the meteor continued to pursue, with very much retarded velocity a path slightly deflected from its former course: it continued to do so for several degrees, and it was, I think, fully a minute after the explosion that several of us almost simultaneously exclaimed, "It is falling." It resembled the expiring light of one globe of a rocket charged with golden rain. The falling motion was very slow. I think it was visible for two minutes after the explosion, but though we tried more than once to consult our watches, the light was insufficient. HENRY H. HIGGINS

Rainhill, Oct. 11

AN exceedingly brilliant meteor was seen here about 8.50 on Sunday evening, which was so bright that it attracted general attention, the light from it being as strong as an unusually bright flash of lightning, but more white. On looking up I saw, near the zenith, a long almost straight and uninterrupted ribbon of light, somewhat pointed at the end towards the north-east. After watching it for some time and noticing that it retained its brilliancy, I began slowly counting, and counted up to twenty before there was any noticeable diminution of luminosity. The last portion visible was the end opposite the pointed end, which appeared as a faintly luminous patch as large as the apparent disc of the moon. I consider that, from its first appearance, it was visible from 80 to 100 seconds. A. BALDING

Wisbech, Oct. 11

Rainbows

As a supplement to the description of a "Double Rainbow," published by Prof. Tait in NATURE, vol. x. p. 437, the following diagram may be of interest to your readers. It represents a phenomenon which was seen here a few days ago, and one which I should think must be of very rare occurrence.

FIG. 1.

It will be observed that all the four bows were incomplete, but this only arose from the accidental cause mentioned by Prof. Tait. The two extra bows were due to reflection from a calm sea.

It may perhaps be remembered that about eighteen months ago I published in NATURE a verbal description of a rainbow similar to that now figured by Prof. Tait; only I was fortunate enough to see the bows complete and extraordinarily brilliant. Hence there were three bows, thus:—

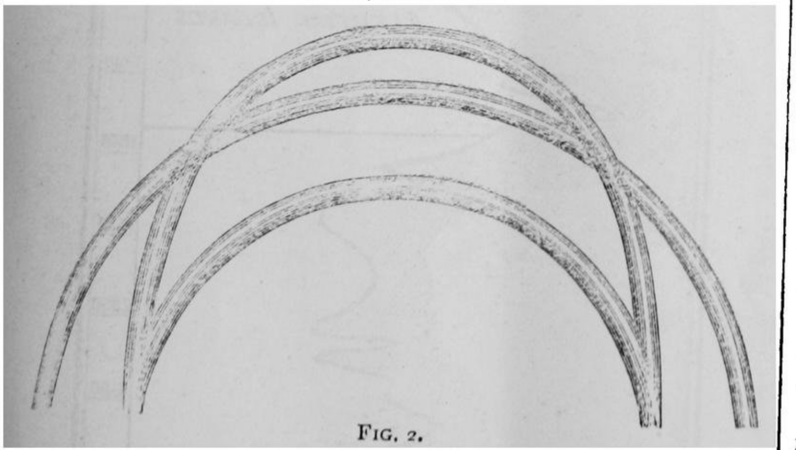

FIG. 2.

I presume that the presence of the fourth bow, as shown in the first diagram, is to be accounted for by the reflection from the sea having been sufficiently bright to give rise to a double concentric bow. GEORGE J. ROMANES

Dunskaith, Ross-shire, Oct. 3

IN reference to Mr. Tait's letter in NATURE, vol. x. p. 460, it may interest some of your readers to hear that our party saw a very perfect lunar rainbow at North Malvern, Worcestershire, on the evening of July 27, this year. The bow was so perfect that the colours were easily distinguishable—that is, of course, the main colours. The appearance lasted about five or ten minutes (10.35 to 10.45 P.M.) JOHN LATCHMORE, JUN.

Leicester, Oct. 12

The Cry of the Frog

WITH reference to the power of the frog to cry out, I may mention that while in India, as I was walking in my garden after dusk during the rainy season, when a peculiar kind of enormous green frog make their appearance for a few weeks, I was surprised to hear a cry exceedingly like that of a baby. On sending for a light I found a large frog, with a small one in its throat which it was apparently swallowing, while the small frog, the snout of which was just perceptible, was shrieking in the way I describe. On tapping the big frog sharply on the back, the little frog jumped out and made off.

Leamington, Oct. 10 J. P. G.

I HAVE on three different occasions heard a frog expostulate in the manner described by Mr. Mott. One did so on being patted inquisitively by a cat; the two others on being examined by a little dog. In each case the frog was of so unusually vivid a yellow as to suggest that it was either a variety of the common frog, or that it was in some unusual condition. Is Mr. Mott's frog equally brilliant? I may add that my three were also Leicestershire frogs.

Oct. 13 E. H.

IT may interest your correspondent who has elicited what he believes to be a cry of fear from a frog, to know that an explanation of this cry—which is probably but the croaking experiment or *Quackversuch* of Goltz—is given at p. 201 of the recently issued volume of the West Riding Asylum Reports in the very remarkable paper by Dr. Lauder Brunton, on "Inhibition, Peripheral and Central." The extract is too long for quotation.

Oct. 13 H. W. P.

I REMEMBER as a boy being rather startled by a shrill wailing cry which proceeded from a small pond, and on running to the spot I found a common snake in the act of swallowing a frog. They were on the surface of the water in the middle of the pool; the hinder part of the frog had already disappeared, and the terrified creature was crying piteously. He proved, however, too big a mouthful to be readily disposed of, and when by the aid of a long stick I interrupted the banquet and released him, he dived away apparently unhurt.

Though I have lived much in the country, I never heard a frog cry but on this occasion. I have often seen them played with, tumbled about, and patted by dogs and cats, as described by your correspondent F. T. Mott, but they have always borne the indignity in silence. F. BADEN BENGER

Manchester, Oct. 10

The Edible Frog

IT is stated in Bell's "History of British Reptiles," 2nd edit., p. 111, that the Edible Frog (*Rana esculenta*) was captured for the first time in this country in Foulmire Fen, Cambridgeshire, in 1843. Mr. Bell received some specimens which on comparison he identified as belonging to the continental species, he having at that time some living ones obtained from France. Mr. Bond, who had written to the *Zoologist* on this subject, said "the whole fen was quite in a charm with their song." Their very remarkable and sonorous croak had procured for these frogs the name of "Cambridgeshire nightingales."

I have recently been informed that this reptile was introduced from France some fifty years ago, and turned loose in the south of Cambridgeshire; and that very recently some one who is partial to the dish called "Frog-pie" has introduced the animal into Norfolk. But I cannot obtain any satisfactory information as to the naturalisation of the reptile. Are those brought into this country dying out? If not, they do not seem to have reached Norfolk, and I cannot find any in this neighbourhood. Is, then, the *Rana esculenta* to be regarded as a British reptile? If any of the readers of NATURE can inform me whether they have obtained it in the Fen district, I should be much obliged.

Wisbech, Oct. 9 SAML. H. MILLER

SOUNDINGS AND CURRENTS IN THE NORTH PACIFIC OCEAN

PREVIOUS accounts of the soundings of the U.S. steamer *Tuscarora* in the North Pacific Ocean, with reference to laying a cable between America and Japan, have described the work accomplished sailing from the Asiatic coast up to lat. 41° 09′ N., long. 144° 01′ E., after two projected routes had been tried and abandoned. From that point the *Tuscarora* went to Hakodadi to obtain a supply of coal, and thence sailed to lat. 46° 38′ N., long. 151° 47′ E., from which point soundings were taken on a backward line to the position which was left to go to Hakodadi; the backward line skirting the shores of the Kurile Islands. All the soundings are taken at intervals of 29 or 30 miles. Upon the new route thus surveyed from Yokohama, for a distance of 1,000 miles, the depths range from 300 to 2,270 fathoms, the greatest declivity being 161 ft. to the mile, between lat. 40° 10′ N., long. 142° 57′ E., and lat. 41° c9′ N., long. 144° 01′ E. The depth gradually increased between lat. 47° 44′ N., long. 154° 15′ E. and lat. 50° 19′ N., long. 159° 39′ E. (a distance of 260 miles), at the rate of about 60 ft. to the mile; the depth at the point last named being 3,754 fathoms. The course thence was through open water between the Kamschatkan coast and the Aleutian Islands; but just before entering the latter group the steepest declivity was found that has been met with during this survey. The preceding and succeeding coasts, each at a distance of 29 miles, gave depths of 2,460 fathoms, while this one, in lat. 52° 06′ N., long. 171° 15′ E., gave 4,037 fathoms, a slope of at least 326 ft. to the mile. Thence to lat. 51° 58′ N., long. 174° 31′ E. (about three miles from Atchka Island), the water shoaled to 332 fathoms, rising at the rate of 187 ft. to a mile. From the last-named position to Tanaga Island the depths ranged from 200 to 1,800 fathoms, including only one remarkable declivity, which was between lat. 51° 08′ N., long. 178° 35′ W., and lat. 51° 28′ N., long. 177° 57′ W., where the slope was 250 ft. to the mile.

Between Tanaga Island and Illiouk, a distance of about 500 miles, the depths nowhere exceeded 1,500 fathoms. The latter place will afford facilities as an intermediate station for the projected cable. Thence the course surveyed was to the north-east, afterward veering to the eastward through Ounimak Pass, toward the locality at which the survey proceeding from Cape Flattery westward left off last autumn, lat. 53° 58′ N., long. 153° W. From Illiouk to lat. 54° 10′ N., long. 162° 39′ W., the depths were small, being at the latter point 44 fathoms. Thence to lat. 54° N., long. 158° 22′ W., a distance of 151 miles, there was a descent of 130 ft. to the mile, the depth at the last-named being 3,359 fathoms. From this point the bed rises, reaching about the same level as that of last autumn's stopping-place—2,520 to 2,530 fathoms—when within 30 miles of that location. The great depth of 3,359 fathoms can be avoided by selecting a line some 30 miles to the northward, where only 2,900 fathoms' depth is found. A series of observations south of the line already surveyed gave greater depths.

Numerous observations were made on currents and temperatures. Along the shores of Kamschatka and the Kurile Islands, in lat. 51° 39′ N., there is a counter-current setting to the south-west, extending to long. 164° E., with a surface temperature of 42° F. Thence to long. 174° E. in the same latitude, with a surface temperature of 46° to 47° F., is the Kamschatka current (a branch of the Japan stream, setting through Behring Straits), which is here about 350 miles in width. It lost 22° F. between the Japan coast and lat. 51° 39′ N. The counter-current within the same limits gained 6° F. The atmosphere lost 18° F. From long. 174 E., proceeding eastward, the cold Behring Straits current with about 42° surface temperature was found, having for its western limits St. Lawrence and St. Matthew Islands. It is inferred that the counter-current of long. 164° is part of the Behring Strait current, having the same temperature, and that it flows

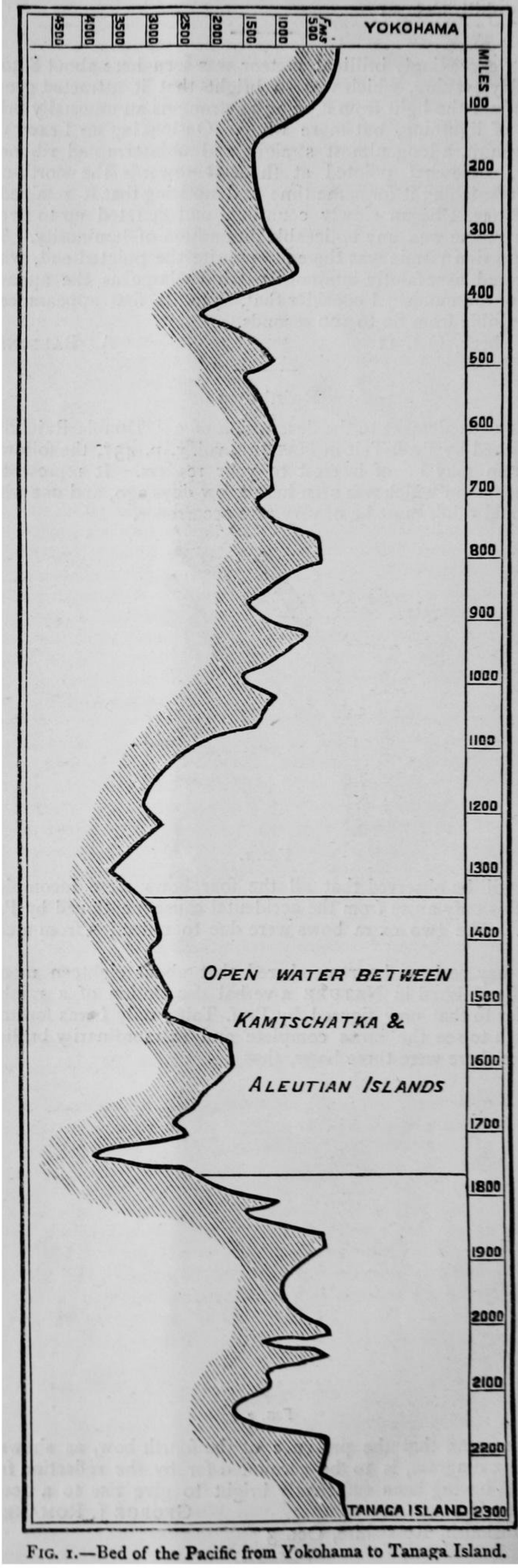

FIG. 1.—Bed of the Pacific from Yokohama to Tanaga Island.

beneath the Kamschatka current; and this belief was confirmed by finding at 30 fathoms' depth and below the latter current one setting to the south-west. On this theory the excess of loss of heat on the part of the Kamschatka current over that of the atmosphere, as stated above, may be explained by attributing it to the cooling

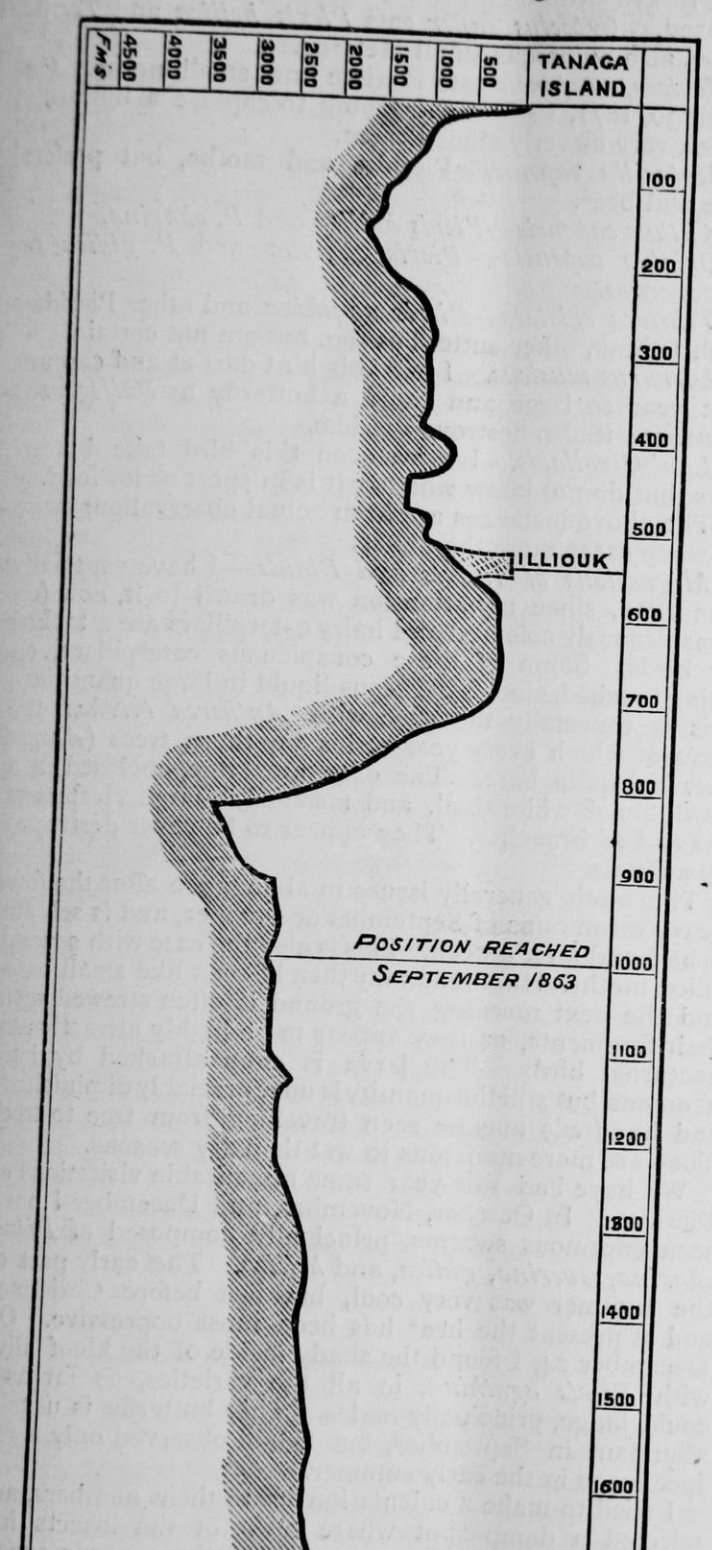

FIG. 2.—Bed of the Pacific, Tanaga Island to Cape Flattery.

effect of the counter-current beneath. It may here be mentioned that the northernmost limit of the Japan stream was 51° 12′ N., long. 178° 20′ E.

The coincidence of observations on temperatures and currents was very noteworthy. There was found, for instance, at lat. 42° 51′ N., long. 148° 14′ E., a north-east surface current of a half-knot per hour; at 5 to 15 fathoms' depth the temperature was 40·3° F., and in this space the current was marked. In the next 5 fathoms the thermometer fell 6°, and correspondingly the current ceased to be observable at this 20 fathoms' depth. At 200 fathoms a steadily increasing current to the south-west was observed; while from 20 fathoms' depth all the way to the bottom—upward of 4,000 fathoms—the fall of temperature was only 1°. A cold stratum of water was discovered, coming down from Behring Straits as an under-current. Between lats. 51° and 52° and longs. 159° and 169°, this current is at 150 ft. below the surface, and itself of 400 ft. depth. It was perceptible at lat. 42° 47′ N., long. 148° 23 E., but south of that it disappears: lat. 51° 22′ N., long. 162° 20′ E. is believed to be nearly its centre. Now, at the last-named location, at 22 fathoms, the thermometer marked 35·7°; at 75 fathoms, 32°; at 100 fathoms, 35·5°. This current was again satisfactorily defined at lat. 51° 43′ N., long. 165° 25′ E., and there the temperatures were, at 25 fathoms, 37·7°; at 60 fathoms, 34·7°; at 100 fathoms, 37·7°. The bottom temperatures vary from 32° to 33·9°.

Reviewing the results of the entire investigation in respect to currents, the following deductions may be summarised:—The Kuro Siwa or Japan current extends on an easterly course toward the American coast, its northern limit nearly reaching the southern shores of Vancouver Island; and it passes down to the southward in what has been incorrectly denominated the "California cold current." Beneath this an under-current sets to the north-west, and in lat. 50° reaches the surface, after which it sets northward along the shores of British America and the outstanding islands, thence gradually turns to the westward, its direction being affected by the outline of the coast, and exhibits at Sitka a strength of one knot per hour and a northward flow. In lat. 53° 30′ N., long. 157° W., the current, to a depth of 5 fathoms, set to the south-east, and this continued while observations were made during sailing to the south-east; but between that position and the line of the islands the current was to the south-west, and close to the islands to the westward. It is believed that a part of the water carried to the north-west by the under-current, returns in long. 157° to the northern portion of the Japan stream, and mingles with it, returning to the southward along the western shores of America, as part of the surface current; and that the part to the westward of long. 157° which sets toward the south-west, passes as an under-current beneath the Japan stream. A rapid fall in temperature—from 57° to 47° in a few miles—in the Ounimak Pass, shows that the north-west shores of the Aleutian Islands are washed by the cold Behring Straits current, which is somewhat modified in temperature by the inflow of part of the westerly current from the eastward of the islands.

Many observations were made which indicated the relation of prevailing winds to surface currents. The material obtained from the sea bottom off the Kurile Islands had, in addition to the usual ooze, greyish-black sand, gravel, and lumps of lava. Similar sand and gravel were found, and also sponge, in the neighbourhood of the Aleutian Islands. The northern route for a telegraph cable, as finally indicated by this survey, is 4,200 miles in length; the southern, about 6,000 miles. The former route will present great though probably not insuperable difficulties, such as that of the sudden declivity off the Aleutian Islands, the frequent fogs which made even the survey tedious, the embarrassments incident to a northern region, where there are few of the means provided on more civilised shores to meet the requirements of working parties and occasional repairs. The chief merits of the northern route are its comparative shortness and its propinquity to United States territory.

NATURAL HISTORY NOTES FROM SOUTH AFRICA

MR. J. P. MANSELL, of Brooklyn, near King William's Town, Kaffraria, has sent us the following notes, the results of his own observation in the district in which he dwells:—

In November 1869 I was looking for some louries in the Bedford forest. My gun was loaded with a very small charge of dust shot. A large troop of monkeys was disturbing my birds, and, annoyed with them, I fired among them at random. One fell on the branches of a bush, shrieking piteously. I ran up to put the poor thing out of its agony, when to my great surprise I saw the whole troop (about twenty) rushing down the trees and screaming savagely. They came so close to me that I had some trouble in killing the wounded one, as I was afraid they would attack me. Were monkeys substituted for toucans in the frontispiece to Mr. Bates's Travels, the scene would be almost identical.

A few days ago, while working in my garden, my attention was drawn to a part of the kloof by the angry screams of birds, indicating a snake. On approaching the spot where the birds were collected, I noticed several dashing at a low shrub. As I approached the dark underwood an Ahætulla, whose characters do not agree with any published description, rushed out. I struck it with a spade, and then, curious to see how the birds would act, I flung it half alive over a branch of a tree, still holding it by the tail.

There were a great many bush birds, but especially noticeable were *Turdus olivaceus* and a Campephaga.

The first-mentioned birds kept flying round in a wide circle, dashing with open wing and beak at the snake, and screaming with the utmost fury. With such violence did these birds dash at their enemy, that more than once the bird fell on the ground from the branch against which it struck. The birds continued attacking the snake for some minutes.

While at the Koonap in 1865 I saw the common *Juida phœnicoptera*, which had a nest in the trunk of an Euphorbia, screaming with fury, and attacking boldly a red mierkatje, which was endeavouring to plunder its nest.

We have heard so much of the mysteries of fascination, &c., that I think a comparison of the cases I have given, together with the well-known way in which birds pursue owls, cats, and cuckoos, shows that it is more fear than anger which gives the subtle snake an easy prey, than any mysterious mesmeric influence; and I believe the immunity of the mongoose from the poison is owing to its closely-pressed, tight, wiry hair.

The wattles of turkey-cocks are a decided disadvantage to them in a warm country like this. I have lost two from the flies laying their eggs in the wounds inflicted by rival birds.

Some four or five years ago, when in Fort Beaufort, a friend of mine amused me by bringing a stuffed leopard to a pet monkey he had. The monkey would scream with terror, shut its eyes, and hide away in my friend's coat. On touching it with the claws its terror was piteous. On removing the leopard it would slowly peep out, and on catching sight of it close its eyes tight.

I do not think it is generally known that baboons in Karoo districts, such as Richmond and Hopetown, destroy in dry seasons numbers of lambs. A farmer told me that they were more destructive than any other wild animal in the district.

There are likewise two varieties of the leopard called respectively Berg and Riviere Tiger, from frequenting mountains or rivers; and the baboons are said to vary according to their locality. It is said that baboons will kill a leopard. A friend of mine at the Koonap had a tame baboon which shouldered arms and wrapped itself in a sheepskin like a Kafir.

South African Birds which eat Butterflies.—As some doubt was thrown on this subject in your journal a year ago, I now give the result of a year's careful observation, and I have little doubt the number could be greatly increased. *Cypselus caffer* eats *Pieris hellica* and *Terias rahel*, also numerous small Heterocera.

Zosterops capensis eats Pieridæ and small moths. On April 30, 1871, I saw a pair trying to capture a butterfly, which very cleverly eluded them.

Motacilla capensis—Pieridæ and moths, but prefers flies and bees.

Anthus capensis—*Pieris hellica* and *P. charina*.

Oriolus capensis — *Pieris charina* and *P. gidica* or *P. severina*.

Tchitrea cristata—*Pieris agathina* and other Pieridæ, and, I think, other butterflies too, but am not certain.

Dicrurus musicus. I saw this bird dart at and capture last year so large and rapid a butterfly as *Philogroma varanes*; it also destroys Pieridæ.

Lanius collaris. I have seen this bird take butterflies, but do not know whether it is in sport or for food.

The above instances are from actual observation, made in some cases more than once.

Migrations of Insects and Plants.—I have especially remarked, since my attention was drawn to it, how few conspicuously coloured and hairy caterpillars are attacked by birds. Some of these conspicuous caterpillars, on being touched, eject a nauseous liquid in large quantities; this is especially the case with *Antherea tyrrhea*, the larva of which every year strips my thorn trees (*Acacia horrida*) quite bare. The eggs are large, enclosed in a hard, bluish white shell, and fastened in large clusters at the end of branches. They appear to be never destroyed by animals.

The moth generally issues in abundance after the first heavy warm rains of September or October, and is seldom to be found after a week. This is also the case with several allied moths. Hundreds may then be seen like small bats, and the next morning the ground is often strewed with their fragments, as they appear to be highly attractive to nocturnal birds. The larva is often attacked by ichneumons, but still the quantity is unappreciably diminished, and hundreds may be seen travelling from tree to tree. They are more numerous in wet than dry seasons.

We have had this year some remarkable visitations of Pieridæ. In October, November, and December I have seen enormous swarms, principally composed of *Pieris charina, severina, gidica*, and *hellica*. The early part of the summer was very cool, but just before Christmas and at present the heat has been most oppressive. On December 24, I found the shady inside of the kloof alive with *Pieris agathina*, in all the varieties, as far as I could judge, principally males. This butterfly is usually abundant in September, but I had observed only a few specimens in the early summer.

I tried to make a calculation as to their numbers, and selected a damp spot where most of the insects had settled. I counted on a spot about three yards square about fifty; many were hidden by stones and leaves. They were about equally abundant in other parts of the kloof, and I think, therefore, that fifty would be a fair average. As the kloof is 500 yards long, or thereabouts, and in some parts thirty yards broad, I think the following calculation (allowing for the extra attractiveness of the moist spot observed), namely, twice the quantity, calculated at three yards broad, would give a quantity of 16,666 for the entire kloof. The kloof was full of birds chasing these insects, and two days later the number was greatly diminished.

As far as my observations go, I am led to believe that there are three kinds of migrations among butterflies. The principal relates, for the most part to Pieridæ, such as *Pieris hellica, gidica, severina, mesentina*, and *Colias electra*. These butterflies seem to be attracted to cultivated ground, old kraals, or cleared forest. On all these spots vast numbers of weeds—many introduced plants—spring up, and appear to be particularly attractive to these insects. These migrations take place as often against as with the wind.

Papilio merope, *Philogroma varanes*, *Pieris eriphia*, *Pieris zochalia*, and *Terias rahel* appear to migrate in the direction of the wind, and there are one or two others which perhaps do so also, such as *Junonia pelasgis*. When resident at Bedford I never saw these butterflies in seasons of drought, but so soon as the southerly winds with rain became abundant a few stragglers might be met with.

P. gidica, *mesentina*, and *severina* likewise share in these southerly and northerly migrations.

Lastly, there are the sudden and almost inexplicable appearance and disappearance of certain species, such as *Callidryas rhadia*, *Diadema misippus*, &c., although I see Mr. Bowker mentions having seen vast swarms of the former in the Drakensberg taking a south-easterly course. During the last two years I have hardly seen a specimen of these two butterflies. The year before they were most abundant. I would here remark that I do not remember to have noticed in any entomological work, although the shapes of butterfly wings are accurately described, an account of their peculiar and finely graduated modes of flight.

Thus, in Pieridæ, *P hellica* flies generally in open ground from flower to flower, but alternately rises and falls and shifts from side to side. *Terias rahel* has a similar flight, but slightly more direct; *Colias electra* a similar flight, but I think a trifle swifter.

Cypselus caffer, which preys on these, generally describes semicircles, flying backwards and forwards over the grass in the manner of a scythe working, and it is curious to see how artfully these butterflies, by a slightly higher or lower flight, escape their much swifter winged enemy.

The different varieties of *P. agathina* in like manner vary. The whiter specimens (♂) frequent more the open, and are a trifle swifter in their flight than the gamboge and ochreous varieties, or their ♀. The latter frequent wooded spots, and rise and fall through the foliage like dead leaves, and it is surprising to see how with sluggish movements a slight change of direction saves their lives. *P. gidica*, *mesentina*, *severina*, and *zochalia* in like manner vary among themselves in their varieties and in different localities.

I was particularly struck, when on a visit to Cradock in 1867, by the difference of size and colour and flight in *Mesentinas* in the Karoo from that of those in the Bedford Forest.

Papilio cenea, which my observations confirm as being the female of *merope*, as so admirably indicated by Mr. Trimen, changes its flight in a remarkable manner when quitting the forest for the open plain. In the forest its flight is remarkably weak, especially if contrasted with that of its mate; whereas over open plains it rapidly rises out of sight, and soars away like some bird of prey with scarce a flutter of the wing.

Junonia pelasgis, *archesia*, and *amestris* are in like manner very similar in their flight, but differ with the difference of the localities they frequent; *J. archesia* being intermediate between the forest-frequenting *J. pelasgis* and the plain-loving *J. amestris*. It is also remarkable that where *J archesia* frequents the same spots as *J. pelasgis*, its markings approach that species; where it delights in open country, about Kaffraria, it is bluer, and slightly more like *J. amestris*.

Nymphalis xiphares.—The ♀ of this species is much weaker in its flight than the male, and its coloration, as is known, differs remarkably. Last year I captured it in company with *P. merope* and ♀ *P. echerioides*, and was much struck at the time by the similarity of colour and pattern, although its imitation is much coarser than that of the other two butterflies.

A long series of ♂ and ♀ *Meropes* shows a remarkable variation, hardly two specimens being alike, and in one ♂ a small oblong black spot closes the discoidal cell of the fore-wing.

On some occasions plants of different orders seem suddenly to increase and then almost disappear for a season or so. This is notably the case with some Compositæ.

As I mentioned in a letter to Mr. Darwin, two species of Gramineæ, *Tragus aliena* and *Briza geniculata*, appear to spring up in the course of locust swarms. I at first was rather sceptical on this subject, but by carefully watching the locusts and examining *sour veld*, where these grasses do not generally grow, I believe that the opinion of the farmer who first called my attention to it is correct.

Mr. Darwin, I believe, raised plants from locust dung which I sent him, but I am not aware to what species they belonged.*

JEFFRIES WYMAN, M.D.

IN the death, on the 4th ult., at Bethlehem, N.H., of Prof. Jeffries Wyman, American biological science has lost one of its most able comparative anatomists. Prof. Wyman was born on Aug. 11, 1814, at Chelmsford, Massachusetts, and had therefore just completed his sixtieth year. His father was a well-known physician. He graduated in Arts at Harvard University in 1833, whereupon he commenced his medical education, and took his degree in 1837, after which he for two years continued his studies in Paris. Returning to Boston he became for some time curator of the Lowell Institute, where he commenced his career as a teacher by delivering two courses of lectures on comparative anatomy and physiology, in which he first gave indications of the lucid and well-ordered expository powers which throughout his life made him so great a favourite with all hard-working students. In 1844 he became Professor of Anatomy and Physiology in the Medical School of Richmond, Virginia, in connection with the Hamden-Sidney College. In 1847 he succeeded Dr. Warren as Professor of Anatomy in Harvard University; at which time, from the materials brought from Africa by Dr. Savage, he had the earliest opportunity of describing that naturalist's new genus of anthropoid apes, the Gorilla (*Troglodytes gorilla*, Savage). This professorship he held till 1866, and it is to him that Cambridge, Mass., almost entirely owes the development of its excellent Museum of Comparative Anatomy.

Prof. Wyman had for many years been a sufferer from phthisis, which necessitated his removing to the warmer climate of Florida during the winter months, and the cessation of his lectures and practical work. When the Peabody Museum of American Archæology and Ethnology was established, the founder appointed Prof. Wyman one of his trustees, and the board committed the incipient museum to his charge and direction. The seventh annual report of this institution, just issued, was his last production. Most of his written contributions to science are contained in the Journal and Proceedings of the Boston Natural History Society, of which for many years he was the president; and in the "Smithsonian Contributions to Knowledge."

Prof. Wyman was a man of singular modesty and truthfulness. His bad health was always in the way of his will to work; and his desire of completely mastering whatever he undertook, together with a certain over-cautiousness, has limited the number of his works. It is not remembered that he ever had a controversy. In his death a gap has been caused which it will be difficult to fill.

* See 'Origin of Species,' 6th ed. p. 1?7.

LECTURES IN NATURAL SCIENCES AT CAMBRIDGE

THE following lectures in Natural Science will be given at Trinity, St. John's, Christ's, and Sidney Sussex Colleges, during Michaelmas Term 1874.

On Electricity and Magnetism.—By Mr. Trotter, Trinity College, in Lecture Room No. 11. (Mondays, Wednesdays, Fridays, at 11, commencing Friday, Oct. 16.) Students desiring to attend this course are requested to call upon Mr. Trotter at his rooms on or before Thursday, Oct. 15. Students of Colleges other than Trinity, St. John's, Christ's, and Sidney, can be admitted on payment of a fee of 1*l.* 1*s.*

On Elementary Organic Chemistry.—By Mr. Main, St. John's College. (Tuesdays, Thursdays, Saturdays, at 12, in St. John's College Laboratory, commencing Tuesday, Oct. 20.) Instruction in Practical Chemistry will also be given. Students desiring this instruction are requested to call upon Mr. Main on or before Monday, Oct. 19. For members of Trinity, St. John's, Christ's, and Sidney, the fee for the lectures in Chemistry is 10*s.* 6*d.*, and for instruction in Practical Chemistry 1*l.* 1*s.* per term; for others the fees are respectively 1*l.* 1*s.* and 2*l.* 2*s.* per term.

On Palæontology.—(The Protozoa and Cœlenterata.) By Mr. Bonney, St. John's College. (Tuesdays and Thursdays, at 9, commencing Thursday, Oct. 15.)

On Geology.—(For the Natural Sciences Tripos. Preliminary matter and Petrology.) By Mr. Bonney, St. John's College. (Mondays, Wednesdays, and Fridays, at 10, commencing Wednesday, Oct. 14.) A course on Physical Geology will be given in the Lent Term, and on Stratigraphical Geology in the Easter Term. Papers will be given to Questionists every Saturday at 11, but the first paper will be set on Wednesday, Oct. 14, at 11, when arrangements will be made for further instruction, should it be required. Students desiring to attend any of these courses are requested to call upon Mr. Bonney on or before Wednesday, Oct. 14. Students of other Colleges can be admitted to these lectures on payment of a fee of 1*l.* 1*s.* for the course. An Elementary Course will be given in the Lent and Easter Terms.

On Vegetable Morphology.—(For the Natural Sciences Tripos.) By Mr. Hicks, Sidney College. (Tuesdays, Thursdays, and Saturdays, at 11, in the Taylor Lecture Room, beginning on Tuesday, Nov. 3.) The lectures during this term will be on the Morphology of Phanerogamia. For members of the above Colleges the fee for this course is 1*l.* 1*s.*; for others 2*l.* 2*s.*

A Course of Practical Physiology and Histology.—By the Trinity Prælector in Physiology (Dr. Michael Foster) at the New Museums. Lectures on Tuesdays, Thursdays, and Saturdays, at 10, commencing Tuesday, Oct. 20. Fees for the Practical Class, 3*l.* 3*s.*; for the course of two terms, 5*l.* 5*s.* This course is intended for those who have gone through a course of Elementary Biology similar to that given last Easter Term.

Also a short course of lectures on the *Physiology of Nutrition*, on Wednesdays, at 10, commencing Oct. 21.

On the Comparative Anatomy of Invertebrata.—By Mr. Martin, Christ's College. (Mondays, Wednesdays, and Fridays, at 12, commencing Friday, Oct. 16.)

NOTES

AMONG the Fellowships at Trinity College, Cambridge, awarded on Saturday last, one was given for proficiency in Natural Science. Although thrown open to the whole University, it was gained by a member of Trinity College, Mr. Francis M. Balfour, B.A., the circumstances of whose election are worthy of notice. The Fellowships at Trinity College are awarded according to the results of an examination held specially for the purpose, and not as in other Colleges, according to the positions gained by the candidates in the University Examinations or Triposes. The Natural Science Fellowship was no exception to this custom: a special examination in Physics, Chemistry, and Biology, was held in order to test the proficiency of the candidates. But it had previously been announced that the examiners were prepared in estimating the proficiency of the candidates to take into consideration records of original work in the shape of published memoirs or unpublished dissertations, and to be guided by the value of these as well as by the ordinary examination answers. In other words, the authorities of Trinity College formally declared that they were prepared to bestow a Fellowship *as a reward for, and thus as an encouragement to, research.* Mr. Balfour's success in his candidature was, we understand, due to the value attached to the original memoirs, chiefly on embryological subjects, sent in by him, as well for their actual worth as for the future of which they gave promise. We congratulate him and the Natural Science School at Cambridge on the result. The deadening influence of the examination system at Cambridge, great as it is in mathematics, bears with fearful effect on all Natural Science studies. The cramming necessary for success in a competitive examination such as the Natural Science Tripos, renders original research for the time being impossible, and goes far to destroy all power for it in the future. Mr. Balfour had the courage to commence original work before he had taken his degree. In spite of warnings that he was endangering his position in the Tripos, he chose the better part, and spent in research the time he might have frittered away in cramming for an examination. Incidentally he has thereby won a Fellowship. We trust that his example will be followed by other students, and the example of Trinity College by other Colleges, so that henceforward on the one hand early research may be the rule at Cambridge instead of the exception, and on the other the injurious effects of the Fellowship system may be lessened as much as possible.

THE following changes are proposed to be made in the Council of the Mathematical Society for the ensuing session:—Dr. Hirst, F.R.S., the retiring president, will become a vice-president, and be succeeded by Prof. H. J. Stephen Smith, F.R.S. Mr. Spottiswoode, F.R.S., having served his term of office as vice-president, will become an ordinary member of the Council. The vacancies caused by the retirement of Prof. Henrici, F.R.S., and Mr. J. J. Walker, have been filled up by the selection of Mr. R. B. Hayward and Mr. W D. Niven. The Society has nearly completed its tenth year, and has had as presidents De Morgan, Sylvester, Cayley, Spottiswoode, and Hirst. It would, we think, be difficult to find more fitting representatives of the mathematical ability of this country, should the day ever arrive, in this day of congresses, for holding an International Congress of Mathematicians. When the Society started into existence on Jan. 16, 1865, there were, we believe, not more than two similar societies in the world; now, each year adds to the ever-lengthening chain. It is a singular and sad coincidence that as the present president on his accession to the chair had to announce to the members the great loss the Society had sustained through the death of the lamented Dr. Clebsch, so, too, as he vacates his office will it be his last task to tell of the decease of Dr. Otto Hesse; though in this sad case mathematicians have to mourn the loss of a man full of years and honours. The Society is thus left without a representative of the great body of German mathematicians in its list of foreign members. The election of the new Council will take place on Nov. 12. The above-named changes are those suggested by the present Council, and will be submitted in the usual way to all the members of the Society for their approval.

ANOTHER College for Working Women is about to be opened. Its inaugural meeting is announced for Friday evening, at No. 5, Fitzroy Street, Fitzroy Square. The committee aims at enabling women who can spare a few evenings a week to obtain gradually a liberal education. The fees are very low, and the classes numerous. A library and a coffee and conversation room will, it is hoped, promote friendly intercourse amongst the members. Many have promised to teach or occasionally lecture, amongst whom we see the names of Mr. J. G. Fitch, Mr. Thos. Hughes, Q.C. (Principal of the Working Men's College), Mr. Litchfield, Prof. Seeley, Mr. George Macdonald, Miss Chessar, Miss Keary, and Dr. Morell.

IN connection with the *conversazione* held at the opening of Owens College, Manchester, there was an interesting loan collection brought together through the energy of Mr. W. B. Dawkins and Mr. R. D. Darbishire. A large series of plants of the coal measures was exhibited, with specimens of the nearest known living representatives systematically placed among them to convey an idea of the kind of vegetation from which coal was formed. Near these was a geological model of a boring for coal. A quaint set of stone mining tools from the abandoned workings of the Alderley Edge copper mines, and wooden and iron tools found in Derbyshire, were of especial interest. The local geology was well illustrated, and there was a fine collection of fossil bones which have been recently discovered in a fissure at Windy Knoll, near Castleton, by Mr. Pennington. A well-supported endeavour was made to illustrate the latest stage of vertebrate life in England as known by the remains found in bone caves and river deposits; and an extensive collection of mammoth, bear, lion, and other bones was the result. Near these were cases containing early implements fashioned by man. A Manchester paper says of these cases: they "include all the evidence as to the antiquity of man given by both river and cave, and we need little scientific assistance to find out that these constitute the most complete set of stone implements ever got together. To make their evidence clearer, illustrated and explanatory diagrams are placed near them. The collection of neolithic flints is wonderfully complete. A case sent by Mr. John Evans carries us from the rough model to the same instrument more exquisitely finished and moulded."

THERE is hope for scientific education when a sporting correspondent of the *Field* discourses on it. The gentleman in question has recently visited the Mining Academy of Freiberg, which he thus describes:—"Students of every nationality are found here, and there is no doubt that if a man likes to work he can learn a great deal, as some of the most celebrated professors in Germany are teachers. The only requisite for a student entering the Academy is that he should know a little German. This rule is not very strictly observed, and anyone of ordinary intelligence ought to pick up the requisite amount in a month, or six weeks at the outside. There are different courses open to the option of the student, such as an assaying course, chemical course, surveying and mining course, &c. These are each charged separately for, the fees ranging from 3*l*. to 5*l*. each. The blow-pipe course, given by the famous Prof. Richter, is 6*l*. Foreign students are charged 5*l*. yearly extra; German students are exempt from this tax. Living in Freiberg is excessively cheap. The whole [illegible] the most lasts three years, but I imagine that a man would do far better by picking out a few particular lectures and finishing in eighteen months or two years. Now, after the course, what return has a man for his money? I unhesitatingly answer that a man who has worked hard for two years at Freiberg ought to be able to go anywhere in any mining district in the world and command his 500*l*. a year. So many people are troubled with questions as to what to do with their younger sons, that I am sure that sending them to Freiberg, and giving them a first-class profession in two years for 375*l*. or 400*l*., is well worth their consideration. To such a man, *i.e.*, one well educated at Freiberg, the whole of the American continent, and, indeed, most of the world is open. Now that England is so 'blocked' it has become a necessity to go further afield, and probably mining engineering and assaying offer about the very best openings to an enterprising man. Immense deposits of metal are daily being discovered in Colorado and the south-western States, while Chili and Peru are short-handed." The sporting correspondent is correct as far as he goes, and it is perfectly true that many young Englishmen have gone to Freiberg, but he does not seem to know that the British Government has just fitted up a small cellar in Jermyn Street, and that with such a national metallurgical laboratory as this, of which of course the country should be justly proud, there is no fear that more young Englishmen will seek to perfect their studies in a foreign land.

FROM a paper on "Some indigenous Tuscan Remedies," read by Mr. H. Groves before the recent Pharmaceutical Conference, it would seem that plants furnish a considerable portion of the medicinal products in use in that country. Many of the plants enumerated are well known as medicinal plants in other parts of Europe. The Chamomile (*Matricaria chamomilla*), for instance, is said to be found in the cupboard of every housewife, being used as a calming antispasmodic, and also applied hot externally for relieving pain. A custom very prevalent in Tuscany seems to be the administration of herb-juice in spring, which is prepared daily by many herbalists, and is also ordered by medical men. *Nasturtium officinale*, known as Crescione, is used in conjunction with *Cochlearia officinalis* in the composition of herb-juice. This latter plant, though indigenous, is also cultivated to some extent. The flowers of the Wallflower (*Cheiranthus cheiri*), under the name of *Viole gialle*, or Yellow Violets, are boiled in olive oil and used for enemata. With regard to products other than plants, the writer remarks that viper-broth is gone out of fashion, and the pharmacist is spared keeping those reptiles and the pincers with which they were handled. Snail poultices are still used in the country. The snails are applied alive, the shell being crushed or partly removed, and the snails set upside down on a piece of coarse paper; they are then sprinkled with a little vinegar and applied at once to the soles of the feet, on which they produce an irritation greater than mustard, and which is supposed to be efficacious in some cases of fever.

THE British Association partook this year somewhat of the nature of a Church Congress; the real Church Congress has, *en revanche*, partaken somewhat of a British Association meeting, Prof. Pritchard having communicated a paper to it giving his view of certain conclusions to be drawn from our present knowledge of molecules, and quoting in support of it the honoured names of Herschel and Clerk-Maxwell. As we are informed that the paper will be published *in extenso* elsewhere, we need not refer to it at any length here; but there is one bit of it which, coming from a clergyman and a professor at Oxford, we cannot refrain from quoting. He suggests that it would be a good thing "if in the study of every manse throughout England there were found a well-used microscope, and on the lawn a tolerable telescope; and, best of all, if those who possess influence in our (*b*) That [illegible]ities could see their way to the enforcement of a small modicum of [illegible] practical knowledge of common things on the minds of those who are to go forth and do battle with the ignorance and failings of our population, and to spread light throughout the land. A little knowledge of the ancient elements, fire, air, earth, and water, would save many a young clergyman from the vanity of ridiculous extremes, and from the surprise of the more wisely and widely educated among his flock." Surely no one will think that with regard to the Universities Prof. Pritchard is asking too much! He then goes on: "Depend upon it, whatever may be our suspicions or our fears, the pursuit of the knowledge of the works of nature will increase, and increase with an accelerated velocity; and if our clergy decline to keep pace with it, and to direct it into wholesome channels, they and their flocks will be overtaken, though from opposite directions, by the inevitable Nemesis of disproportion."

A SEVENTH edition of "The London Catalogue of British Plants" has just been issued. The chief differences between this and the preceding edition is in a renumbering of the specific names, and in those changes of technical arrangement which have now rendered it necessary to abandon the original series of numbers. The first edition of 1844 was closely adapted to the "British Flora" of the late Sir Wm. Hooker. This seventh edition is made to correspond with the "English Botany" of Dr. Boswell-Syme, third edition, as far as to the grasses. For the ferns and allied orders, the arrangement and nomenclature of Dr. Hooker's "Student's Flora" are closely followed. The species of Chara are taken from Prof. Babington's "Manual of British Botany." Mr. Backhouse is followed in the species of Hieracium; Prof. Babington in the Rubi; Mr. Baker in Wild Roses.

THE *Gardener's Chronicle* quotes from the *Illustration Horticole* that the recent International Botanical Exhibition at Florence yielded a net profit of 1,000*l.*, and that the disposal of this sum to the best advantage of horticulture is under consideration.

A SCHOOL of Mines has been established by the Territorial Government at Golden, Colorado, one of the best places in the country for practical instruction.

THE Sixth Annual Report on the noxious, beneficial, and other insects of the State of Missouri has been issued.

MR. EDWARD BELLAMY, of the Charing Cross Hospital, has been appointed to deliver the course of lectures on the Anatomy of the Human Form, at the South Kensington Museum.

"ELEMENTARY Astronomy, or Notes and Questions on the Stars and Solar System" (Van Voorst), a small text-book for the use of schools, by C. C. Reeks, contains a great deal of recent and accurate information in small space, and seems calculated to serve the purpose for which it is intended.

THE additions to the Zoological Society's Gardens during the past week include an Australian Rail (*Rallus pectoralis*) from New Holland, presented by Mr. J. Harris; a Gannet (*Sula bassana*), European, presented by Mr. R. R. B. Norman; a White-winged Trumpeter (*Psophia leucoptera*) from S. America; a Dusky Monkey (*Semnopithecus obscurus*) from Malacca; a Pinche Monkey (*Midas œdipus*) from New Granada; a Bonnet Monkey (*Macacus radiatus*) from India, deposited.

ON THE NECESSITY FOR PLACING PHYSICAL METEOROLOGY ON A RATIONAL BASIS.*

I WISH at the outset pointedly to disclaim originality in the main ideas to which I propose here to invite attention. The subject of my paper has occupied the thoughts of many men of science, with some of whom I have been in communication regarding it for several years. But though the conclusions to which I wish to lead you are the product of many [illegible] *ertebrata*.—By bound to accept to the fullest extent the [illegible] bility of bringing them forward at the present time and in the present form.

The branch of inquiry which has been very unsignificantly named Meteorology (meteoric phenomena being but slightly and remotely included in it) deals with the climate of the globe, and seeks to explain the vicissitudes of temperature and moisture, storm and calm, to which that globe is exposed. It is a subject of the highest importance to mankind generally, as affecting health, navigation, and agriculture; and possesses an interest acknowledged by every individual, from the savage to the *savant*, influencing as it does the personal well-being and daily comfort of all. Everyone discusses, and thinks himself competent to discuss, the weather.

My present object necessitates a broad classification of this department of inquiry into two main branches. The more obvious one of these, for which a fitting name has yet to be proposed, relates to changes of weather from day to day, and to the varieties of climate found in different localities. I shall not say much on this branch of Meteorology, but shall confine myself principally to the other main division, which has been named—I believe, first by Prof. Balfour Stewart—Physical Meteorology. Under this term are included, amongst other important matters, fluctuations in the seasons; the causes, external to the earth, which occasion or contribute to them; and the laws which regulate these fluctuations. The opinion is daily gaining ground that this branch of Meteorology has been unduly neglected, that it offers a magnificent field of inquiry and discovery, and that its vigorous cultivation must greatly aid the solution of those more limited and local inquiries to which observation has been hitherto more particularly applied. My present object is to urge the cultivation of this wide and almost unoccupied field of research and to point out some of the steps which should now be taken to that end.

It will be necessary for my purpose first to advert to some of the most elementary facts connected with Meteorology. Speaking in general terms, there are but four principal elements concerned in the production of all meteorological phenomena—the familiar elements of antiquity—fire, water, earth, and air. The part played by each is obvious to every observer.

Water, sucked up by heat from the ocean, and from the land which has imbibed it, falls again from the clouds in the form of rain, undergoing alternately, through excess of heat, evaporation and condensation. *The earth*, a great recipient of both heat and moisture, gives up each gradually and silently, and helps to maintain equability of temperature and of humidity. *The air*, set in motion by heat locally applied, becomes breeze, or wind, or storm, according to the amount, duration, and locality of that heat. In each of these three cases we see that an external force, heat, plays a conspicuous part. Can either of the three named elements, Water, Earth, or Air, perform its functions without the aid of that external force? Have they any innate power, enabling them to act independently of each other, or of all external forces? Will water, if left to itself at an unchangeable temperature, rise into vapour and fall in rain? What power resides in the earth to cause meteorological phenomena? It may possibly be replied that it boasts volcanic power, but as this exists only locally, it can play but a small part in the great economy of the whole earth. The internal heat of the globe may also be claimed as an independent attribute of the earth, and it may be so—but on this question we have as yet but very little reliable knowledge, though much interesting speculation. It may, however, be stated that, as an explanation of leading meteorological phenomena, the internal heat of the globe has not as yet been allowed much, if any, weight, though its use as a modifier of such phenomena may be considerable. As to the air, no innate power has hitherto been assigned to it. We may therefore, without much risk of error, regard water, earth and air, for the purpose of the present inquiry, as three forms of inert matter, capable of exercising independently no force whatever, but when acted upon, either separately or in combination, by heat, capable of producing the most stupendous results.

We come now to this heat—the sun. Has this any innate power? It seems almost need[illegible] answer the question. The most familiar occurrences attes[illegible] his paramount influence: the alternations of day [illegible] the march of the seasons, the dai[illegible] warmth [illegible] all bear testimony to his all-per[illegible] [illegible] superfluous to state facts which are almost truisms. But would it not seem to follow as a matter of course, needless to dwell upon, that such being the paramount influence of the sun, its study must be the first and most anxious object of solicitude to the meteorologist? Yet such is not the case. Obvious as are the facts I have briefly indicated, they have led to no such result. The reports and volumes of observations emanating from bodies and institutions charged with meteorological researches often do not contain even the name of the sun, and it may be broadly stated that the great central source of heat, and therefore of all meteorological activity, receives little or no attention in that capacity. I do not prefer this as an indictment against those to whom I refer. Many reasons may be assigned for their total neglect of the sun. Perhaps amongst the most valid is the fact that instrumental appliances fitted for the purpose have not, until within a comparatively recent period, existed.

* By Lieut.-Col. A. Strange, F.R.S., Inspector of Scientific Instruments to the Indian Government; a paper read at the British Association.

Another powerful reason no doubt is to be found in the difficulty with which even cultivated scientific minds can be brought to recognise, as a truth to be practically acted on, that no science stands alone, that all are intimately connected by nature, and that the classification and separation of various branches of inquiry is an artificial arrangement of man, adopted for the more convenient division of labour.

The time seems to have arrived when we ought to apply this truth to the science of meteorology, and to bring to its aid a class of researches calculated to provide it with that secure and rational basis of which at present it is absolutely destitute.

Before passing to a consideration of the steps which seem necessary to this end, I will touch slightly on one of the objects the hope to attain which fully justifies their being taken. I allude to the hope that we may thereby find some explanation and some law for the fluctuations of the seasons.

In a given locality, on a given date, the sun, to whom we ascribe so predominating an influence, attains, year after year, the same elevation above the horizon, and being at the same distance, presents the same angular area. If the sun, as that date annually recurs, were in all other respects the same, we should have a right to expect an annual recurrence of the same weather, unless some disturbing cause, of which we have at present no knowledge, were known to exist. I do not say positively that the sun being a constant force, we should have this constancy in the seasons—but what I do say is, that if the sun be not a constant force, we have no right to expect constancy in the seasons. The first question, therefore, should be: Is the sun a constant force? Does it, year after year, at the same date, present the same unvaried surface? We know that the contrary is the case.

We know that the surface of the sun's disc is never free from spots, and that these spots are constantly changing in number, size, and position: we know that whatever law may govern them, their period of change and return is certainly not annual.

We know also that the general surface of the sun is covered with markings called faculæ, which are perpetually changing, and which have not an annual period. We have also learnt, within two or three years, by the aid of the spectroscope, how at any time to examine the exterior gaseous envelope of the sun, which formerly could only be seen during a total eclipse, and we now know that the famous red prominences of which on those rare occasions we obtained only a fleeting glimpse, on being studied at our ease, without interruption, reveal evidence of activity in those regions of the most stupendous sublimity, darting out, in a few seconds, flames many thousands of miles in extent. Further, in examining the spectrum of the solar light with improved spectroscopes assisted by photography, we find that thousands of lines exist there of which hitherto we had no knowledge—and quite recently the researches of Norman Lockyer tend to throw a doubt on the fixity and constancy of some of these lines.

We have here evidence which conclusively proves that the sun's surface and surroundings are not maintained in a constant condition. The evidence may not justify us in asserting that as his surface changes so must the force which he pours out on the earth necessarily change also; but it certainly justifies us in entering on a systematic examination of that question with the appliances which modern physical astronomers have contrived for the purpose.

In what, then, should this systematic study of the sun consist? Up to the present time the spots have been the main object of study. Most valuable observations on these have been made, of which those of Carrington, of Howlett, of Selwyn, and of the Kew Observatory under the auspices and direction of Warren De la Rue and Balfour Stewart, may be mentioned as the most complete and most long-continued. But excellent as these series are, and great as is their value, this consists chiefly in their having shown the extent and character of the work that has to be done. They labour under the unavoidable defect of frequent interruption by cloudy weather—about two-thirds of the year are thus lost in England, and the evidence afforded by the remaining one-third is diminished in value. But even some of these researches have now been discontinued—in the case of Kew, for want of the requisite funds.

The conclusion arrived at by those who have devoted themselves to the subject is that *a daily record* of the changes taking place on the sun's surface is necessary. I will here advert only to the changes in the spots. These we already know do not take place arbitrarily: they gradually increase in aggregate area to a maximum, and as gradually decrease to a minimum—their period having been provisionally fixed at about 11½ years. But this period has been derived from observations of all the spots visible, without discrimination—and the "spotted area" is the aggregate area of all such spots. There is, however, reason to suspect that if it were possible to trace each individual spot throughout its existence, from its first formation to its final disappearance, there would be found to be different classes of spots having very different durations and perhaps very different maximum and minimum periods; and a reduction of these classes separately might, and probably would, result in a considerable modification of of the present 11½ years cycle, and possibly in the discovery of other cycles, at present masked in the period determined from all spots taken indiscriminately. But hitherto the absence of anything approaching a daily record of the spots has precluded any attempt to classify them. What is true of the spots is also probably true of all other manifestations of solar energy.

With respect to sun-spot researches, it fortunately happens that the photographic records need not be all taken at the same station. The record of one day taken in England can be combined with the record of the next day taken at the other side of the globe. Hence, in order to obtain this daily record it is only necessary to select a certain number of stations in localities such that there shall always be clear weather at one of them. India offers peculiar facilities for such a selection of stations, owing to the great variety of climate to be found in that country during the same period of the year. Perhaps four or five such stations would suffice for India, and if absolute continuity of record could not be obtained by them, the deficiencies could easily be made good by stations in our colonial possessions.

I think it hardly necessary that I should state that in advocating this system of continuous solar record I do not intend that other methods of meteorological research, now in use, should be abandoned. It is obvious that both methods must be employed. Whether present methods do not admit of considerable extension and improvement, is a very important question, on which, however, I do not here propose to enter. Nor do I intend to discuss the question whether the sun stations now advocated should not also be meteorological stations in the ordinary sense. This, like many other such questions which will have to be settled, is an administrative detail, which I shall not step aside from the consideration of fundamental principles to discuss.

It is scarcely necessary to point out that such a system of daily solar record as I have indicated is beyond the reach of individuals, and must, if attempted at all, be established and maintained by the State. The degree and direction in which the State should aid the advancement of science has been much debated of late, and the British Association has contributed powerfully, by obtaining a Royal Commission presided over by the Duke of Devonshire, to the solution of this difficult problem. As I have taken a part in these discussions, and have given considerable attention to the subject, I may perhaps, without impropriety, here state what appear to be the principles applicable to the particular case we are now concerned with.

The first principle is that private enterprise should not only be allowed the most perfect freedom from interference or competition by the State, but that it should be encouraged and aided in every possible way.

The second principle is that the State should step in where private enterprise fails, and itself conduct scientific research, whether observational or experimental, subject to the following main conditions:—

(*a*) That the probable results of the research will be beneficial, in the widest sense of that term, to the community at large, or to the various departments of the State.

(*b*) That the research is too costly, or commercially too unremunerative, to be undertaken and vigorously prosecuted by individuals.

(*c*) That the research requires continuous uninterrupted work extending over very long periods, and conducted by systematically organised establishments.

Probably no case could be mentioned as so completely satisfying these three conditions as that of researches affecting closely every interest in the community, needing for their conduct a number of well-equipped establishments, maintained, not merely for many years, but certainly for generations—possibly for centuries. This is work which it is futile to demand from individuals.

I wish to guard against being thought to assert that the study of the sun will certainly solve all the enigmas of meteorology. I do assert that the strongest possible *primâ facie* has been made out against the sun as the principal ringleader in meteorological agitation—and that there are ample grounds for putting him on his trial. Let us however suppose the impossible case of his absolute acquittal, I maintain that this negative result would be worth all the labour of obtaining it—eliminating, as it would do, one, and that the most conspicuous of probable causes, and so narrowing our inquiries to those that remain. The more likely event, however, will be that whilst the sun will be proved to be the chief promoter of these disturbances, his accomplices, and their various degrees of participation, will be dragged more prominently before the light.

Nor do I desire that the "innate power" I have attributed to the sun, and denied to other elements, should be misunderstood. I have used the term as the only one available to mark strongly the relative influences at work. I by no means intend to use the word "*innate*" in an absolute sense, or even to imply that the forces of the sun are self- enerated and self-maintained. The object of this paper is a strictly practical one, and is not to be taken as intended to contribute one word to speculations on the constitution of the sun. But though disclaiming speculation, I may, on behalf of my practical object, point out that we already possess what may at least be claimed to be presumptive evidence that the sun is not exempt from external influences. I allude to the remarkable apparent connection which the researches of De la Rue, Stewart, and Loewy, have established between the behaviour of the sun-spots and the positions of some of the planets, particularly Venus, the Earth, and Jupiter. I say that the mention of a result so well calculated to excite speculation, aids my practical object. I mean that by following up the hint given us by these most remarkable researches, we may be led to a more complete knowledge and more philosophical conception of the structure of the universe.

And I would here remark that I have urged the study of the sun from the meteorological point of view in order to give a practical justification for the adoption of definite practical steps. But that study is recommended by even higher considerations still, by the insight it must give us into cosmical relations, and the help it will afford us in seeking to understand something, if not of first causes, at least of causes of the highest order that our limited intelligence can grasp and reason on.

The more one reflects on the neglect of the sun justly chargeable against us, the more one wonders at it. It is like the case of a man placed before a steam-engine for the first time, and seeking to learn its principle and action by counting and measuring the bolts, screws, and rods, without giving a moment's attention to the source of power—the furnace and boiler. What they are to the steam-engine the sun is to us, and it is astounding that men should dare to undertake a solution of the complex and mysterious fabric which surrounds us without giving a foremost place in their investigations to the source of all material life and power.

Civilisation has been variously described and defined. It seems to me to imply above all things *completeness.* It aims at supplying all wants, at removing all obstacles to thought and to action, at making good all deficiencies, at remedying all evils moral and material, at guarding against all dangers, at promoting all beneficence, at extending and perfecting all knowledge. Science, as the most potent guide and instrument of civilisation, needs also to be complete. A harp with broken strings can discourse no music,—a chain with unconnected links can sustain no weight. Science, as our President so eloquently impressed upon us in the address with which he opened this Section, is one and indivisible. It has been broken up by man into its various recognised branches to serve his convenience and to assist the weakness of his intelligence; but nothing, as the same authority told us, is more subversive of truth and more hindering to progress than to regard these subdivisions as representing the actual order of nature. There must be doors of communication between the observatory, the laboratory, and the mathematician's study. The isolation of particular fields of research is no longer tolerable: each passes, however indirectly and insensibly, into the other through that "border land" which, as our President reminded us, "recent investigation has shown to be so fertile of discovery."

The study of the sun stands on this "border land." It belongs but very partially to the domain of the ancient astronomy, it possesses some holding in the provinces of chemistry and geology, and more still in that of physics, it claims as its right (as what branch of science does not ?) the devotion of the mathematician, and it rules almost supreme in meteorology.

This study asks to be recognised and provided for. How much longer will the demand be disregarded?

*IN WHAT WAY AND AT WHAT STAGE CAN TECHNICAL INSTRUCTION BE BEST INTRODUCED INTO OUR SYSTEM OF NATIONAL EDUCATION**

IT will simplify the consideration of the subject, the discussion of which I have been requested to introduce, if we admit frankly that in England at any rate (I am glad to believe that Scotland is more fortunate) we do not possess a system of national education. Such a system, as I conceive it, should afford to all the children of the nation adequate elementary instruction, and, moreover, should offer to all, so far as their capacities and other circumstances will enable them to take advantage of it, full opportunity for further mental cultivation. There are lying before me the calendars of two German schools for boys of the middle class intended for a mercantile or industrial career: the Friedrich-Werder Gewerbe, or Trade School of Berlin, and the Real Schule, under the direction of Dr. Schellen at Cologne. The courses of each of these institutions following after some preparatory teaching in an elementary school or at home, where reading and writing together with a little arithmetic have been acquired, retain their pupils during nine or ten years; and boys who, according to the reports, were to become mechanical engineers, builders, postmasters, merchants, and chemists, left those schools last July, having attained the ages of seventeen to twenty years. The Real Schule of Cologne, the average number of whose pupils is 580, has 28 masters; the Gewerbe Schule of Berlin, averaging 540, has a staff of 32 masters. In every German town of the least importance there are, in addition to the Gymnasium or Classical School, one or more technical schools resembling those of Berlin and Cologne; the numerous Universities and Polytechnic Institutions furnish the requisite staff of teachers. The fees are small. I have no information as to those of the schools which I have quoted, but I find from the prospectus of another very celebrated trade school, that of Barmen in Westphalia, that its school fees for the year are from 3*l.* in the lowest to 6*l.* in the highest class, and that boys whose friends do not reside in the town are boarded for 25*l.* The governments, the municipalities, and private persons vie with each other in placing at the disposal of poor scholars of the elementary schools who have shown superior capacity, the means of continuing their studies in these secondary schools.

I need not describe the elementary schools of Germany and Switzerland; it is now well known that, in them, the children of the poor receive, up to the age of fourteen years, sound elementary instruction, not confined to reading, writing, and arithmetic, but including geography, the outlines of the history of their own and other European countries, a modern language, some elementary teaching in science, and instruction in the religion which their parents acknowledge.

As contrasted with a system of education such as I have referred to and excluding the great public schools, available only to the rich, we have in England for the middle classes schools like those attached to King's and University Colleges, the City of London School, the Bristol Trades School, and, thanks to the Endowed Schools Commissioners, a few efficient or at any rate progressive grammar and endowed schools, amongst which I would more particularly name the school at Giggleswick, near Skipton, as one where instruction in science has been included in the general plan of instruction; and a small number of exceptional private schools in which a praiseworthy attempt is made to adapt the instruction to the requirements of industrial and commercial classes. These schools however rarely retain their pupils beyond the age of fifteen to seventeen years, and when all are reckoned they are utterly inadequate to the wants of the population.

Of elementary school buildings we shall soon have a sufficient number, and it is probable that the duty of the parent to send his child to school will, in some way or other, be in all cases made a legal obligation; but so long as the necessity of rendering our training schools for elementary teachers thoroughly national and efficient is not acknowledged, and so long as the instruction of the children in elementary schools is left in a great measure to the care of other ill-taught children, called pupil-teachers, of from thirteen to seventeen years of age, we cannot hope that our poor will receive proper elementary instruction.

Until the English approach the German schools in number and value it would be vain to expect that technical instruction will be universally accessible, and we can only hope for its gradual

* A paper read before the Social Science Association, Oct. 1, by Mr. B. Samuelson, M.P.

introduction, availing ourselves of existing resources, with such improvements as may be looked for under the stimulus of the increasing interest evinced by some of our great corporations, by the parents themselves, and consequently by the Legislature.

One important step in the right direction has lately been taken:—Although the political chief is still a species of odd man whose duties include the passing of Ballot Acts, the suppression of foot-and-mouth disease, and the negotiation of Washington Treaties, the Government departments of literary instruction and of Science and Art have been placed under the control of a single permanent administrative head.

I understand technical instruction to include, besides the teaching of industrial manipulation, which for our present purpose we may exclude, firstly, drawing, mathematics, and the physical sciences, which are the bases of the industrial arts; and secondly, the application of those sciences and of the art of design to industrial purposes. I should place in the first division such subjects as:—

Pure Mathematics.	Chemistry.	Physical Geography.
Geometry.	Physics.	Biology.
Theoretical Mechanics.	Geology.	Astronomy, &c.;

and in the second—

Building Construction.	Machine Construction.	Metallurgy.
Naval Architecture.	Chemical and Manufacturing Technology.	Agriculture, &c.
Applied Mechanics.		

Although this list is incomplete, it will be obvious that the field is too wide to be covered within the school period, even when the pupils remain at school to the age of adolescence; bearing in mind always that instruction in technical subjects to the exclusion of other branches of a liberal education would defeat its own object. Much more is this the case with children leaving school between the ages of thirteen and sixteen. The choice of subjects must vary with the age at which school instruction is to terminate, and with the future career of the scholar.

A condition precedent, however, to the possibility of technical instruction is a due provision of science teachers. For these we must look, in the main, as to elementary schools, to our training colleges, assisted by such institutions as the Science School of South Kensington, and as to secondary schools, to the Universities, and to institutions like King's College, University College, and Owens College. The training colleges should add a third year to their curriculum; instruction in mathematics and in some of the other subjects which I have included in the first division should be part of the obligatory course; and no elementary school containing, for example, 100 children and upwards should, after a certain date, receive the Parliamentary grant on results, unless it had a teacher who had passed satisfactorily in Geometry, in Physical Geography, and in Physics or in Biology. A man thus qualified, having become familiar with the method of science, could, if he chose, afterwards acquire other theoretical subjects as well as those of application, included in the second division; for instance, machine construction, chemical technology, or agriculture—availing himself for that purpose, as to the first class of subjects, of the annual courses for elementary teachers at South Kensington, or of any other means of instruction which may be within his reach. But if he stopped short at the limited but exact instruction in theoretical science which I suppose him to have obtained in the training college, he would be infinitely better qualified as a teacher than if during that course he had taken up a greater range of subjects superficially. Whether he be competent to teach many subjects or not, the children of the elementary schools whom he is to instruct have not time to acquire more than the rudiments of one or two theoretical sciences. At the same time an elementary teacher, who is qualified to give instruction in the applied sciences, will find employment in adult classes, such as those in connection with the Science and Art Department.

Assuming, then, that every elementary school for 100 pupils and upwards, which would include the principal village schools, had a master or assistant qualified in science, the course of such a school should include, for all the children, linear drawing and lessons on common objects which would be illustrated by locally accessible specimens; the ordinary reading-book should also describe in familiar language the phenomena of nature. Those who are acquainted with the admirable text-books on Elementary Science of Prof. Balfour Stewart, Dr. Roscoe, and others, cannot doubt that the task of compiling such a reading-book will be undertaken by competent hands, as soon as the want of it becomes felt. Indeed, I am not sure that it does not already exist amongst the publications of the Irish National Board. The older children, those between the ages of ten and thirteen, should receive instruction in Physical Geography, in the elements of Trigonometry, and, from the age of eleven or twelve, in the rudiments of Biology or of Physics, perhaps, in some exceptional cases, of both. More cannot be done for them in the elementary school; a few should be drafted into the secondary school; but the greater number would at the age of thirteen become full time-workers in the field, at the bench, or in the factory; possessing, however, as is now but rarely the case, the elementary instruction required for taking advantage in their leisure hours of the science classes which are to be found in almost every district of the United Kingdom. How much may be done there is evident from the success of the Andersonian University in your city, with its 1,400 students, to whose founder belongs the honour of having been, more than a century ago, the originator of scientific instruction to the working classes. Children thus taught from the commencement by such masters, when they afterwards receive instruction in science, would not be subjected to, and would revolt against, cram like that recorded in the Report of the Science and Art Department for the present year, in which Prof. Ramsay, the examiner in Geology, says that "candidates answer one of last year's questions in place of one of this year's, as if they had been specially crammed in last year's examination;" and Prof. Carey Foster, acting with Dr. Tyndall as examiner in Acoustics, Light, and Heat, states that a good number of candidates in the advanced stage "suppose that in order to *damp* the vibrations of a string it is needful to *wet* the string," and "that a ship is the kind of vessel that would usually be employed for containing air."

Amongst other conspicuous examples of adult instruction in science given to the class whose education has been received in elementary schools I may name the lectures for working men of Owens College, numbering more than 600 students, under the gratuitous tuition of the professors of that institution, and those of the Miners' Association of Cornwall and Devon, organised some dozen years ago by Mr. Robert Hunt, F.R.S., Keeper of Mining Records, whose teachers seek out the working miner in his village and make him familiar with the laws of the forces and the properties of the matter with which he is brought into contact in his daily work. But time is wanting to allude further to the subject of adult elementary instruction in science, nor will I enter into the question of science teaching in our great public schools, which has been inquired into by Mr. Norman Lockyer, F.R.S., the secretary of the Royal Commission on Scientific Instruction, whose report will doubtless be forthcoming before long.

In secondary schools, assuming the existence of competent teachers, and that they retain their scholars from the age of eight or nine to sixteen or seventeen—I should commence, as in the elementary school, with lessons in drawing and on familiar objects, and in Physical Geography; and introduce Mathematics, beginning with Geometry at the age of eleven or twelve, continuing it until the pupil leaves school; systematic instruction in the elements of natural science might begin at the age of ten to eleven with Natural History, including Geology; and the six years until the pupil leaves at the age of sixteen or seventeen could be made readily to include successively the elements of that science and of Physics and Chemistry. With the exception perhaps of applied mechanics, it would not in my opinion be possible to include the applied sciences, but the teacher would illustrate his instruction by practical applications. Work in the laboratory is a necessity if a thorough appreciation in kind, however limited in extent, of natural science is to be acquired; but the experience of the Rev. W Tuckwell, of the College School at Taunton, communicated to the British Association, and of others, shows that a school laboratory need not cost more than 200*l*. to 400*l*.

Only in those cases where school education is continued to the age of eighteen or nineteen years would it be desirable to introduce such subjects as building, or machine construction, or chemical technology. In all other cases more real progress would be made by devoting all the available time to theoretical science. The scholar who enters into active life as an apprentice at the age of sixteen or seventeen, would see in the workshop the application of the principles which he would have learnt at school, and, if diligent, he would find opportunities of further study in adult classes, in factories, and in text-books on special subjects. For instruction in the entire range of theoretical and applied science it would be necessary that the student should continue the course, commenced during the school age, at the University or at a Polytechnic Institution such as there is now some hope that the Science School at South Kensington may become.

Although I have excluded instruction in technical manipulation from the subject of this paper, I think it right to add that the students of King's College and of King's College School save much time and drudgery during their pupilage by the practical skill acquired in the workshops attached to the College, and that according to competent observers like Mr. Nussey, of Leeds, the artisans of Elberfeldt, Crefeld, and other continental towns derive great advantage from the schools of design and so-called weaving schools.

I should not fulfil my duty if I were to conclude this paper without acknowledging, though no alarmist in regard to foreign competition, that other nations, less energetic, less rich in accumulated capital and practical experience, and without the advantage of our great mineral resources, are, thanks in a great measure to their superior technical training, making relatively greater advances than ourselves in many branches of industry, and that the conviction of the necessity for such training has not arisen amongst ourselves a day too soon. Happily it has arisen, and in the most desirable quarters. Manchester, by the judicious enlargement of Owens College, to which its merchants and manufacturers have quite recently contributed a sum approaching 200,000*l*.; Yorkshire, by the establishment of the College of Science at Leeds, to which secondary schools of science are to be affiliated; the Company of Clothworkers, by the foundation of scholarships, and the endowment of a chair of textile technology in the Yorkshire College; the University of Durham, and the coal-owners and manufacturers of the North of England, by their joint foundation of the School of Science at Newcastle; Oxford, by its patronage of the College to be established at Bristol; and the Company of Merchant Adventurers, by the aid which it is giving to the Trade School of the same city—are not only directly promoting the higher technical instruction amongst the populations in which their work is done, but will furnish competent teachers to the elementary and secondary schools of their own and other localities. I think there is no fear that a work of such national importance once so actively begun will suffer any relapse; but it will be in the power of this Association to promote by discussion and advice its intelligent and economical organisation.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, Oct. 5.—M. Bertrand in the chair.—The following papers were read:—Researches on the conditions of resistance in cylindrical boilers, by M. H. Resal.—On the exact values of the angles in the crystals of titaniferous iron, by M. N. de Kokscharow.—Report on the machine for freezing by the evaporation of methylic ether, invented by M. Ch. Tellier; and on the preservation of meat in the air, cooled by this apparatus, by the Commissioners, MM. Milne-Edwards, Peligot, and Bouley.—On the temperature of the sun, by M. J. Violle. The author starts with the fundamental equation $a^\theta - a^t = \frac{\omega}{s} a^x$, and from determinations of the intensity of solar radiation assigns the value 1550° to what he calls the *effective temperature* of the sun. The true mean temperature of the surface of the sun is estimated at 2,000°.—Note on magnetism, by M. J. M. Gangain, a continuation of former researches.—Seventh note on the conductivity of ligneous bodies, and of other substances which are bad conductors, by M. Th. du Moncel.—Experimental researches on explosive substances, by MM. Roux and Sarran.—On a register giving continuous indications for the determination of the law of variation of pressures produced by the gases of gunpowder, by M. Ricq.—On the synthesis of purpurine, and of some analogous colouring matters, by M. A. Rosenstiehl.—New observations on the chemical composition of the waters of Bagnères-de-Luchon, by M. E. Filhol.—Method of determination of copper by means of titrated liquids, by M. Pr. Lagrange.—Comparative and critical examination of the hypotheses which have been advanced to explain the figure of comets and the acceleration of their motion, by M. H. Champion. The author attempts to show in this memoir: (1) that a force directed along the radius vector develops in the two opposite parts of an elliptical orbit separated by the major axis, two tangential components of contrary signs, of which the effects are exactly compensating; (2), that the force gives rise to a third component opposed to gravitation, of which the final result is to increase the dimensions of the orbit; (3), it is shown that at the distance at which comets' tails commence to be seen, the rays of the sun would not produce an appreciable elevation of temperature in a highly rarefied substance.—On the comparative chemical composition of the different parts of the vine when healthy and when attacked by *Phylloxera*, by M. Boutin.—Experiments made at Cognac on phylloxerised vines with the coal-tar recommended by M. Petit, by M. P. Mouillefert.—Experiments made at Montpelier with the same substance, by M. Alph. Rommier.—Observations on the points gained by science concerning the known species of the genus *Phylloxera*; a letter from M. Signoret to the perpetual secretary.—Observations concerning the recent communication of M. Balbiani on the different known species of the genus *Phylloxera*, by M. Lichtenstein.—Trial of infection of a healthy vine by putting *Phylloxera* in contact with its roots, by M. Delorme.—On the means proposed to check the propagation of *Phylloxera*, the method of uprooting in particular, by M. P. Naudin.—Experiments on a method of treatment of phylloxerised vines, by the sap of a Euphorbia, by M. L. Balme.—On the appearance of *Phylloxera* in the canton of Geneva, and on different curative measures proposed, by M. E. Ador.—The Minister of Foreign Affairs transmitted further details of the recent eruption of Etna.—M. Dumas announced that the news received from the first four Transit of Venus expeditions was satisfactory on all points.—On the pretended Saharan Sea, by M. A. Pomel.—Observations on the ancient central sea of the Tuniso-Algerian Sahara, by M. Virlet d'Aoust.—On the theory of curves in space of n dimensions, by M. C. Jordan.—Electro-diapason of variable period, by M. E. Mercadier.—Electro-spectral tube, or "fulgurator," for the observation of the spectra of metallic solutions, by MM. B. Delachanal and A. Mermet.—Note on supersaturation, by M. Lecoq de Boisbaudran.—On the action of bromine on certain alcohols, by M. E. Hardy.—Note on the production of oxamic acid by the oxidation of glycocol, by M. R. Engel.—Action of heat on diphenylmethane and phenyl-toluene; on the products of the reduction of benzophenone, by M. Ph. Barbier.—Curious association of garnet, idiocrase and datholite, by M. J. Lawrence Smith.—Balloon meteorological observations, by M. G. Tissandier.—Note on the spectroscopic observations made during the balloon ascent of Sept. 24, for studying variations in the extension of the colours of the spectrum, by M. W. de Fonvielle.—On the feeble influence which diluvian waters have exercised on the formation of the valleys of the Paris basin, by M. E. Robert.

BOOKS RECEIVED

BRITISH.—Synopsis of an Arrangement of Invertebrate Animals in the Free Museum of Liverpool, with Introduction by Rev. H. R. Higgins (Marples).—Babington's Manual of British Botany. 7th edit. (Van Voorst).—Mineralogy: Frank Rutley, F.G.S. (T. Murby).—The Sanitary Condition of Oxfordshire: G. W. Child (Longmans).—Symond's Rainfall for 1873.—Sixteenth Report of the East Kent Natural History Society (Canterbury).—Amateur's Photographic Guide Book: Stillman (Smith, C.D.).—The Principles of Modern Pantheistic and Atheistic Philosophy: C. A. Row (Hardwicke).—Micrographic Dictionary. Parts xiii. and xiv.: Griffith and Henfrey (Van Voorst).

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