THURSDAY, SEPTEMBER 22, 1904.

THE SCOPE OF ANTHROPOLOGY.

Science de l'Homme et Méthode anthropologique. By Alphonse Cels. Pp. vi+467. (Paris: Félix Alcan; Bruxelles: J. Lebégue et Cie., 1904.) Price 7 francs.

THERE has always been a great difference of opinion about the scope of the science of anthropology. Huxley's view was that anthropology deals with the whole structure, history, and development of man. Another authority subdivides the subject as follows:—(1) Man's place in nature, *i.e.* his relation or standing to the animal kingdom as a whole; (2) his origin, whether from one pair or otherwise; (3) classification of races, with delineation of their chief characteristics; (4) antiquity of man; (5) language; (6) development of civilisation as a whole. Mr. Fallaize, in a paper read last year before the Anthropological Institute, has given the following main subdivisions:—(A) man's place in nature; (B) physical structure; (C) physical functions; (D) specifically human activities; and makes divisions (2) and (3) of the previous classification subdivisions of his class (A).

These examples will illustrate the wide variety of opinions held by authorities about the scope and the method of classification of the subject-matter of anthropology. The impression one gets from the consideration of these schemes is that it is not within the capacity of any one man to be an anthropologist in the widest sense of the term. The definitions of the scope of anthropology given above include many separate sciences, such as anatomy, physiology, philology, archæology, which in themselves are sufficient to absorb the energies of any single student, and which were in existence before the science of anthropology was created. Many branches of the study of man must therefore as a matter of practical convenience be abandoned to special sciences, and if a science of anthropology is to have any *raison d'être* it must be content to take the results of the studies of the anatomist, the physiologist, the psychologist, the archæologist, &c., and to coordinate and correlate these results with the view of discovering the more general laws of human nature.

The sciences at present generally included among anthropological studies have not been created by a subdivision of the whole subject-matter relating to man into watertight compartments, but usually some end of special theoretical or practical interest has formed a centre around which the science has been built up. For example, the interest excited by the perception of the great differences in the characteristics of different races has led to the creation of the science of ethnology, and the object of this science is to utilise all knowledge which may throw any light on the question of race. It overlaps without completely including prehistoric archæology, anthropometrics, psychology, and many other sciences.

This appears to be the only practical way of studying anthropology, but there can be no doubt that a great deal might be gained by the careful setting out of the whole of the subject-matter which, in the widest sense, could be taken as included in a complete science of man. New subjects of study which were previously overlooked may in this way be suggested, and new subordinate sciences created.

This very useful work has been well done by M. Cels in the book under review in a very suggestive though somewhat diffuse and fanciful style. About one-half of the book is devoted to an exposition of the logical methods of science, and as these methods are not more specially applicable to anthropology than to any other science, this part of his work might very well have been omitted or given in a much more condensed form. The same information might be found in any modern treatise on logic.

When we come to the part of M. Cels's work which is more especially relevant to its title, we find his subdivision of the subject-matter of the science of man interesting, suggestive, and well worth the attentive study of anthropologists.

Anthropology, according to M. Cels, is to be divided in the first place into two main subdivions, namely, the study of the nature of man and the study of the life of man, *i.e.* man is to be studied from the static point of view and from the dynamic point of view. In the second place, each of these main divisions is again subdivided into the study of the intrinsic and extrinsic conditions of their existence. Finally, each of these four subdivisions is again subdivided into three, in the first of which man is regarded as a Unity, *i.e.* as an individual, in the second as a Duality, *i.e.* as made up of body and mind, and thirdly as a Harmony, *i.e.* as a bisexual being which is only completed by the union of the two sexes for the reproduction of the species.

This division of the subject-matter of anthropology appears in some respects a little fanciful, but it is very plausibly worked out by M. Cels in his treatise: The author's view of anthropology is that it includes the study of the body and the mind of man, in their constitution as well as in their activity. This part of the subject is fairly well covered by the existing sciences of anatomy, physiology, and psychology. M. Cels also emphasises the necessity of studying the environment of man, namely, the earth on which he lives, his fellow-men and lower animals, and any other influence which reacts on his organism and on its activity. The effects of the moral as well as the material environment must be studied. The study of the influence of environment on mankind has not received so much attention from anthropologists as it deserves.

As a matter of practical convenience, the detailed study of the body and mind of the individual man must be abandoned to anatomy, physiology, and psychology; anthropology can only concern itself with the coordination of the results of these sciences. It may compare the anatomy, physiology, and psychology of different races of contemporary men, or of men of the present with those of the past. This field is to a great extent covered by physical anthropology, prehistoric archæology, the study of culture, and experimental psychology.

Though M. Cels has devoted so large a part of his work to the logical methods of anthropology, he tells us little or nothing of the immense advance that has been made in recent years in anthropometrics. No science makes much progress until precise measurement is applied to the characters the distribution and correlations of which are to be ascertained. Measurement has been applied to the body of man for more than fifty years, but only within the last few years has a statistical method been devised which enables us to give the true interpretation of the vast amount of anthropometric statistics that has been accumulated. But the work of Galton and Karl Pearson receives no notice from M. Cels in his work on the science of man and anthropological method; we are referred rather to the works, published fifty or more years ago, of Cuvier, Krause, and Saint-Hilaire, whose ideas on co-relation were mere shadows of the precise knowledge we now possess.

As a highly abstract and suggestive exposition of the nature and scope of anthropology, the book deserves a place in the library of the anthropologist.

J. GRAY.

PROGRESS IN THE CHEMISTRY OF FATS.

Chemical Technology and Analysis of Oils, Fats, and Waxes. By Dr. J. Lewkowitsch, M.A., F.I.C. Third edition, re-written and enlarged. Two vols. Pp. xxviii+1152. (London: Macmillan and Co., Ltd., 1904.) Price 36*s.* net.

IN this, the third edition of Dr. Lewkowitsch's well known work, there is naturally much that was not included in the former issues. And since the second edition was itself a somewhat bulky tome of more than eight hundred pages, the author has wisely divided the present work into two volumes, corresponding broadly to the analytical and technological branches into which his subject resolves itself.

Briefly, the first volume deals with general principles, the second with individual products. In the earlier chapters there is a discussion of the theory of saponification, and a description of the glycerides, esters, alcohols, and acids which form the proximate constituents of oils, fats, and waxes; the rest of the first volume is mainly devoted to an account of the chief physical and chemical methods now employed in the examination of these substances. In the second volume, after a short generalised description of their commercial methods of preparation, the individual oils, fats, and waxes are dealt with. Under each article are given its source, characteristic features, physical and chemical constants, and such miscellaneous information as the technical uses of the product and the nature of its probable adulterants. Finally, the last two chapters embody an account of modern manufacturing processes employed in the various industries —soap, candle, rubber, glycerol, and so on—for which the raw materials are furnished by oils and fats.

To specialists, the foregoing summary will show the present arrangement of what is now the standard English book of reference on the subject. To chemists who have not followed the progress of the chemistry of the glycerides very closely it may be useful to indicate a few of the more recent developments which, among many others, Dr. Lewkowitsch has described or referred to in the book under review.

Looking back over the work of the last few years, what strikes one as being the most notable advance in the chemistry of fats is the recognition of mixed glycerides as frequent if not normal constituents of fats and oils. Since the days of Chevreul, until quite recently, these latter bodies have been almost universally regarded as mixtures of simple triglycerides —usually triolein, tripalmitin, and tristearin. True, evidence was adduced more than a quarter of a century ago, on the one hand by Bell and Lewin, and on the other by Blyth and Robertson, which pointed to the fact that butter-fat contained a mixed glyceride, oleopalmitobutyrin. But, probably owing to the difficulty of isolating and definitely proving the identity of such compounds, the observation long remained almost unnoticed. During the last few years, however, the mixed glyceride oleodistearin has been obtained by Heise from kokum butter, stearopalmitin by Hansen from tallow, oleopalmitostearin and oleodipalmitin by Klimont from cocoa-butter, and daturodistearin by Kreis and Hafner from lard. This does not exhaust the list; and, indeed, the probability is that on further investigation mixed triglycerides will be found in most oils and fats. Several have also been synthesised, chiefly by Guth; thus two isomers of stearodipalmitin have been prepared, the α variety from α-monostearin and palmitic acid, and the β form from α-dipalmitin and stearic acid.

Another point of interest is the frequent, and perhaps general, occurrence of fat-splitting enzymes such as steapsin in both vegetable and animal oils and fats. The author is strongly in favour of the view that the rancidity of fats is due initially to hydrolysis of the glycerides by these ferments. To this, however, one possible objection suggests itself. Enzymes are usually destroyed at moderately high temperatures—*e.g.* maltase at 80°. Is there any evidence to show that lard or tallow prepared at steam-heat, or any fat specially raised to a temperature of, say, 95° to 100°, does not turn rancid? If it does not, so much the better for the enzyme theory of rancidity. If it does, one would still like to have other evidence that the enzymes present are capable of withstanding these higher temperatures.

As regards the analytical chemistry of fats, the most important among recent advances is undoubtedly Hehner and Mitchell's method of determining stearic acid. It is not an ideal process, and shows at least one anomaly; but it does place in the chemist's hands a valuable and long-wanted means of estimating, with reasonable accuracy and expedition, the proportion of one of the most frequent constituents of natural glycerides. To the same investigators, following Hazura, is also due the working out of what promises to be a very useful aid to the study of unsaturated glycerides, namely, the quantitative determination of their hexabromide derivatives. Of new methods having an immediate value to the practising analyst there may be mentioned Bömer's phytosterol test for vegetable oils, and Polenske's process for detecting

cocoa-nut oil in butter. No reference, however, is made to the Müntz and Coudon method of estimating the latter adulterant.

These are but a few out of many points of interest which one notes on looking through the book. A number of new illustrations appear, including some, which might be improved upon, of lard, cholesterol, and phytosterol crystals. There are plenty of references to original sources, and the information generally is brought well up to date, several papers issued in the present year being laid under contribution.

"Adulteration," says Dr. Lewkowitsch, "has almost become a fine art." No doubt it has; and in the silent, ceaseless struggle between the cunning of the adulterator and the skill of the analyst such works as the present play an important part. They are very helpful to the former individual, certainly. But to the latter they are invaluable. C. SIMMONDS.

STOKES'S MATHEMATICAL AND PHYSICAL PAPERS.

Mathematical and Physical Papers. By the late Sir G. G. Stokes. Vol. iv. Pp. viii+378. (Cambridge: The University Press.) Price 15*s*.

IT was on all grounds fitting that the continuation of this reprint should be entrusted to Prof. Larmor. The energy with which he has addressed himself to the work is shown by the fact that, although it is little more than a year since the death of his great predecessor, we already have a new volume in our hands, containing, in addition to the text, some valuable annotations and a selection from some very interesting correspondence.

The papers here reproduced range in date from 1853 to 1876; they are about forty in number, and, as a rule, are shorter and more restricted to special points than is the case in the previous volumes. There are, however, some notable exceptions. From the mathematical point of view the most considerable is the memoir "On the Communication of Vibration from a Vibrating Body to a Surrounding Gas." Perhaps the highest testimony to the excellence of this investigation is that Lord Rayleigh, who usually transforms and illuminates what he touches, in this case found, as he tells us, no better course open to him than to print page after page *verbatim* in his "Theory of Sound." The memoir is important, historically, not solely for the interest of the particular phenomenon which it explains, but as leading the way for a whole series of investigations in acoustics, optics, and electricity, in which we have to deal with waves diverging from point- or line-sources. Especially characteristic of the author is the labour expended with a view of reducing the results to a definite numerical form. From another point of view the paper may be regarded as forming one of the long series (some other members of which fall in the present volume) in which Stokes attacked the difficulties of the Bessel functions; other methods of dealing with these have since been devised, but it is mainly through his labours that these functions have become real and intelligible instruments of the mathematical physicist, instead of merely abstract analytical expressions.

We also find in this volume the classical "Report on Double Refraction," presented to the British Association in 1862. This has entered into so many discussions, that it is unnecessary to refer to it in detail. Although elastic theories of light no longer excite the same interest, the report is still worthy of careful study, not only on intrinsic grounds, but also as a masterpiece of criticism, and as an embodiment of the clear and judicial mind of its author.

Among experimental investigations, we may note the very important paper "On the Long Spectrum of the Electric Light," and the verification of Huyghens's law of refraction in uniaxal crystals, which has served as a touchstone of optical theories.

A short, but extremely acute, paper "On the Effect of Wind on the Intensity of Sound," read before the British Association in 1857, was unfortunately unnoticed and forgotten until the explanation was rediscovered, and extended so as to include the effect of variations of temperature, by Osborne Reynolds in 1874.

It will not be supposed that the numerous other brief memoirs which we are obliged to pass over without special mention are unimportant. To the scientific worker the value of such a collection often resides chiefly in these minor investigations, which are otherwise in danger of being overlooked, as in the instance just referred to.

As has been already mentioned, the editor has appended a few notes, chiefly of a historical character. This delicate task has been exercised with great judgment and restraint. He has also included a most interesting correspondence between Stokes and Thomson on the early history of spectrum analysis. It is clear that long before Kirchhoff's first publication on the question Thomson was in possession of the leading ideas of the subject, and foresaw its wonderful possibilities, and that he had, moreover, publicly expounded these things in his lectures at Glasgow. But whilst he is emphatic that he derived his knowledge from Stokes, the latter is equally positive that his share in the matter was limited to suggestions which he had himself not been able to follow out with the same confidence. The whole correspondence is a lesson of magnanimity on both sides; we feel, as Lord Rayleigh recently expressed it, that the theory of spectrum analysis is practically there, but it would be contrary to the whole spirit of the friendly debate to attempt to analyse further how much of the merit of this prevision belongs to one rather than to the other. One point, however, remains indisputably associated with the name of Stokes, viz. the hypothesis that special absorption of light is due to coincidence, or approximate coincidence, of the period of the light waves with a proper period of a molecule. Hypotheses of this kind have played a great part in recent theories of anomalous dispersion and the like; but there can be no question as to their original source.

The remaining papers are to be included in a fifth volume, together with the biography by Lord Rayleigh recently issued by the Royal Society. We are also

encouraged to look forward to a selection from Stokes's scientific correspondence, which cannot fail to be of the highest interest.

All readers will combine in congratulating Prof. Larmor and the Cambridge Press on the success of this most acceptable volume. The portrait by Dickenson, of date 1874, is admirable; we trust that it may be supplemented later on by a likeness of a more recent date, recalling the aspect which is to many more familiar. HORACE LAMB.

ARGENTINE LIVE STOCK.

Argentine Shows and Live Stock. By Prof. Robert Wallace. Pp. 154. (Edinburgh: Oliver and Boyd, 1904.) Price 3*s.* 6*d.* net.

THIS volume is the outcome of a six months' tour of agricultural investigation and inspection in Argentina. While professing primarily to be an account of the annual live stock show of the Rural Society held at Palermo, it includes also notes on other Argentine shows, as well as an interesting description of the chief breeds of cattle, horses, and sheep bred in that country.

The European breeds of cattle represented at the Palermo show were the shorthorn, the Hereford, and the Aberdeen-Angus. Of these, the shorthorn cattle were far the most in evidence. We are told that this breed owes its success to its unrivalled capacity for beef-production where the climate is genial and pasture abundant, and to the fact that it has proved more serviceable than other imported breeds for crossing with the Criollo or native cattle, and so improving their quality for purposes of fattening. Hereford and Aberdeen-Angus cattle are stated to thrive well amid comparatively unfavourable surroundings, and, although not bred to nearly the same extent as the shorthorns, occupy a definite place in the rural economy of the Republic. The Aberdeen-Angus breed has not gained general favour partly because, unlike the other two breeds mentioned, it does not "nick" well with the Criollo cattle.

The horses at the Palermo show included all the more prominent British breeds, the introduction of which has been accompanied by considerable success. It is instructive to note that the importation has in many cases resulted in improvement, apparently owing solely to change of soil and environment. This is especially the case with certain strains of Hackney blood, while among cattle a similar tendency has been noticed for the Hereford breed.

Reference is made to the native Criollo horses, the degenerate descendants, according to most writers, of Barbs and Arabs introduced by the Spaniards at a very early period of the European occupation. Genuine Criollos—only now found in outlying provinces—are characterised by their dun colour, by stripes on the legs and shoulders, and by a dark dorsal band. These Criollos are said to be hardy to a degree, to possess great power of endurance, and, moreover, they are difficult to handle. Doubtless natural selection has been at work eliminating the unfit, with the result that the survivors present all the traits that Darwin and others associated with the ancestors of the common horse. That in the Criollos the mane in no way differs from the mane of Barbs and Arabs suggests that many centuries must have elapsed since horses acquired a long mane, from which it may be inferred that Prjevalsky's horse is not an escaped domestic horse.

It is worthy of note that so great is the vigour of the Criollos that crosses with but little of the native blood prove most useful, owing to their great stamina and endurance.

The section on horses is followed by one on the sheep bred in Argentina. The account includes some interesting information about the early history of the Pampa and Criollo sheep, besides containing suggestions for the improvement of the stock now existing in the country. The Pampa is stated to be derived from the Spanish long-wool, which was a hardy animal, and, like the Dorset Horns of England, in favourable circumstances bred twice a year. The Criollo sheep is a "degenerate offshoot of the Spanish Merino." The most numerous and best represented sheep at the present time are the Lincoln and its various crosses, though a good many other British breeds have been imported with varying degrees of success.

Chapters on dairying and on agricultural machinery follow the description of the live stock.

The book is of value for the interesting descriptions which it contains, and because it affords an idea of the altogether remarkable resources of Argentina for producing live stock. It is freely illustrated by photographs of prize animals taken at the show in Palermo.

OUR BOOK SHELF.

The Old Riddle and the Newest Answer. By John Gerard, S.J., F.L.S. Pp. vi+293. (London: Longmans, Green and Co., 1904.) Price 5*s.* net.

WE have derived much entertainment from Father Gerard's lively chapters. They constitute an ably constructed plea for agnosticism in science. Not Huxley himself was so rigid in demanding exact demonstration of the truth of every statement required to be believed, as is this latest critic of the doctrine of evolution.

Science does not consist purely of mathematical demonstration. Other methods and processes have a perfectly legitimate place in scientific thought. Even in pure logic a door is open to theory and hypothesis; nor are probability, analogy, or even conjecture excluded by those whose conception of the science and art of reasoning is of the widest and wisest kind. We have, of course, to refrain from treating an untested hypothesis, however likely to be true, as an immutable verity; but no one in his senses will fail to recognise that among the dicta of scientific writers there are many degrees of probability, ranging from the practically certain to the merely conjectural. Some of the conclusions of science are as certain as the nature of things will allow; but it is a mistake to attribute to those who lay stress on such certainty a claim of equal respect for every position that to scientific men appears probable.

All this is, of course, perfectly well known to Father Gerard; we can only say that in practice he appears to disregard it. His book is marked throughout by great charm of style and felicity of expression; its main defect is a too evident desire to "play to the gallery." The chapters which contain a root-and-

branch attack on the theory of genetic evolution are as brightly and easily written as the rest; their matter, however, will be entirely unconvincing to those who know the facts. The author has got up his case as a clever advocate might get up his address to a jury; but the cross-examination of witnesses would put a very different complexion on the whole business. Father Gerard seeks to prove too much. His plea amounts to an allegation in the name of science that a science of life is non-existent. F. A. D.

Occurrence of Aluminium in Vegetable Products, &c. By C. F. Langworthy, Ph.D., and P. T. Austen, Ph.D. Pp. v+168. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1904.) Price 8*s.* 6*d.* net.

AFTER a careful perusal of this book we have been unable to arrive at any conclusion as to why it was written. The authors presumably had some reason for compiling a bibliography of the analytical work done on aluminium and its occurrence in plants, animals, and waters, but they give no idea as to their object in their preface.

The book, as already stated, consists of a compilation of work dealing with the occurrence of aluminium in vegetable products, animal products, and in natural waters. In the preface it is stated that "no attempt has been made to comment on the value of individual analyses cited." Now by omitting to do this the book loses any value it might have had, because the references given are so extremely scanty. One or two examples taken at random will give an idea of the style of compilation, *e.g.* on p. 9 we find:—

"Coppola, M. (*Gaz. Chim. Ital.*, 10, p. 9: *Jour. Chem. Soc.* London, 37 (1880), p. 382), found 11.16 per cent. ash in *Stereocaulon vesuvianum*. Of this 1.13 per cent. was Al_2O_3."

Again, on p. 73:—

"Finckh, C. (*Neue. Jahrb. Pharm.*, 34, p. 13; *Chem. Centbl.*, 1870, p. 615; *Jahresb. Chem. Naumann*, 1870, p. 1382), notes traces of aluminium in Ochsenhausen mineral water from Bieberach, Germany."

Both these illuminating passages are taken from the middle of the respective pages. On p. 73 there are seven and a half such references, and on p. 9 eight.

The contents of the book are not arranged in any order, except that the authors' names are placed alphabetically. Consequently, if one looks up tea in the index in order to ascertain whether it contains aluminium, one is referred to p. 32; after a lot of hunting we find tea under the name of Schriddl, P. (*Arch. Pharm.*, 1873, p. 375). . . . Again, if we wish to know the aluminium content of mushrooms, we are referred to p. 15, where we can find nothing about mushrooms, unless *Boletus edulis* is a mushroom; or is poke-weed the American name for mushroom?

In desperation we look up primrose, and are referred to p. 42, and at last we are satisfied; the root of the primrose contains 1.617 per cent., and the flower heads 1.145 per cent., of aluminium oxide.

Works of compilation are often of great value, but they can only be of value when the contents are systematically arranged. To arrange a dictionary such as this according to the names of the authors is absurd. The pitiable thing about the whole matter is that the authors must have wasted a great deal of valuable time, because a compilation of this kind is extremely tiresome and laborious.

Practical Chemistry. By P. A. E. Richards, F.I.C. Pp. viii+136. (London: Baillière, Tindall and Cox, 1904.) Price 3*s.* net.

So long as examinations in practical chemistry of the test-tube order are encouraged by examining bodies, there will be a steady consumption of chemical cram books. The peculiarities of such books are that the student is never allowed to step outside the limits of his syllabus without due warning, and his weary brain is not perplexed with explanations. Like the cattle in the large tinned meat factories, he is driven along a narrow gangway in which he cannot turn round, until he is delivered into the hands of the slaughterer.

Fortunately the more intelligent examining bodies are beginning to realise that the analysis of simple salts does not furnish scientific pabulum of a very nourishing kind; so preparations of a few inorganic compounds and a little volumetric analysis have been added to the syllabus.

The present volume has been prepared to meet the special requirements of the syllabuses of the conjoint board and the preliminary scientific examination of the London University.

It is only necessary to state that the author has completed his task in a thoroughly business-like manner. A student who worked through the book conscientiously might with confidence defy the conjoint examiner to do his worst. J. B. C.

Calculations used in Cane-Sugar Factories. By Irving H. Morse, B.S. Pp. viii+74. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1904.) Price 6*s.* 6*d.* net.

THIS collection of tables was primarily made for the use of the sugar chemists of Louisiana, but it is equally applicable to the operations of every manufacturer of cane-sugar. The work may be recommended to all who seek to use the laboratory as a control of the working of the sugar-house. In every well regulated factory the manager is dependent upon the chemist for information as to the amount of sucrose in the raw juice, the yield of sugar, the losses in manufacture, and whether or not all the available sugar is being extracted from the cane, and the efficiency and value of the laboratory largely depend upon the rapidity and accuracy with which this information can be furnished. The work is thoroughly practical, and is evidently the outcome of many years' experience of sugar testing.

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 intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Colours due to Intermittent Illumination.

MR. C. T. WHITMELL (NATURE, September 1, p. 424) describes a method of producing coloured patches by means of a rotating disc, furnished with a ring of holes. It will be found that the phenomenon can also be produced by intermittent reflection. In the year 1881 I described in NATURE (vol. xxiv. p. 140) a method whereby colour patches of great brilliancy, due to intermittent illumination, were easily produced by viewing sun-light reflected from the polished spokes of a cycle wheel. The relationship between the colour given and the velocity of rotation was clearly marked, and the effects can be easily reproduced by means of the simple apparatus described. In these experiments, a counter was attached to the axle of the rotating wheel, so that the rate of rotation could be accurately determined at the time of observation. The rotation of the cycle wheel was maintained by means of a motor the speed of which could be easily varied. In connection with the phenomenon of the change of colour due to intermittent illumination, several papers of much interest have been published since the year 1882 by Dr. G. Burch, F.R.S. F. J. JERVIS-SMITH.

Trinity College, Oxford, September 13.

Is Selenium Radio-active?

IT occurred to me recently that a possible method of deciding between the two hypotheses which have been brought forward to explain radio-activity, namely, that of *atomic* degradation (Rutherford and Soddy, Ramsay, &c.) and that of *molecular* change (Armstrong and Lowry, *Proc.* Roy. Soc., 1903), lay in attempting to realise radio-activity in the case of an element well known to undergo molecular change readily, but with an atomic weight small enough to exclude the probability of an atomic instability such as is assumed for radium and thorium. Such an element is selenium (at. wt. 79), which suggested itself to me as a suitable material to experiment with because, under the influence of light, it undergoes a remarkable alteration in its electrical resistance and E.M.F. of contact, suggesting an allotropic change of an altogether unusual character. As this change, whatever be its real nature, occurs almost instantaneously (Bellati and Romanese, *Atti R. Ist. Veneto*, 1881; Maiorana, *Atti dei Lincei*, 1894 and 1896), it seemed possible that the rapidity of the intermolecular vibration might be sufficient to cause a radiation similar to that of radium and thorium which, by "ionising" the selenium, would render it conducting. In order to ascertain whether such a hypothetical radiation could be detected photographically, I exposed a piece of selenium, placed on a photographic plate, wrapped in three thicknesses of black glazed paper, during thirty-six hours to the bright sunshine of July. On developing the plate a distinct black stain on a background of clear glass indicated the position the selenium had occupied. The first experiment was made with ordinary vitreous selenium, and the stain, although distinct, was not very pronounced. A second experiment with freshly prepared "metallic" selenium, obtained by heating the vitreous variety at 190° for half an hour and then cooling very gradually to the ordinary temperature, gave a much more intense stain on the negative.

I should have hesitated before publishing these experiments in their present form had I not, since they were made, seen a paper in the *Physikalische Zeitschrift* of August 25 in which similar results are recorded by J. J. Taudin Chabot. This observer, approaching the subject from a different direction, has also been led to the conclusion that selenium in a selenium "cell" is feebly radio-active to the extent of emitting radiations capable of passing through black paper and affecting a photographic plate. It may, of course, be urged that the stain on the plate is due to selenium vapour penetrating the paper in which the plate is enclosed. I am therefore making experiments in which this possibility is excluded. Further, I intend studying the behaviour of sulphur, as it is already known that the other members of the selenium family, namely, oxygen and tellurium, can in certain circumstances give rise to radio-active phenomena. W. A. DAVIS.

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Rare Moths in England.

MRS. THOMAS'S letter in your issue of September 8 is interesting, both as affording definite proof that *Deilephila livornica* does sometimes breed in this country, and as rather tending to support the view that this species enters the country from abroad—for the proximity of Warmwell to the sea is certainly suggestive.

Apropos to rare moths, it may be of interest to state that I recently took a specimen of *Deiopeia pulchella* on the cliff here. This moth used to be so rare that Newman wrote:—"Mr. Doubleday has a single specimen taken at Epping, and we believe there are two or three other British specimens in different cabinets." Since that was written the number of English specimens has, of course, been increased, but I believe that the insect is still considered a rarity; and the scarce occurrence of a weak-flying moth like this, which one can hardly suppose could cross the Channel, and which has been found so far inland as at Epping, is a greater puzzle than the rarity, but occasional comparative abundance, of a strong-flying hawk moth.

F. H. PERRYCOSTE.

Higher Shute Cottage, Polperro, R.S.O. Cornwall, September 12.

THE HEART OF SKYE.[1]

THIS volume of detailed rock-description, raising in its successive chapters questions of profound interest in philosophic geology, proves that the Geological Survey of the United Kingdom is confident that the scientific spirit should permeate its public work. None of the rocks dealt with possesses at present an economic value; most of the area is untraversed by roads, and the exposures are not to be sought in quarries, but in rain-swept uplands, or high on desolate mountain-walls. Yet no detail is regarded as unimportant; the surveyor, for months together, leads a life as hard and remote as that of an Alaskan pioneer; and the result is a book in which the daily difficulties are concealed, while an array of facts is given to us, any one of which may help observation in other and more favoured lands.

Few lands, however, are more favoured in scenery, and the defects of Skye are mainly meteorological. The very audacity with which the black Cuillins rise from the edge of the Atlantic seems a temptation to the summer-storms. Yet the glaciated surfaces allow of small decay, and Mr. Harker directs our attention to the remarkable freshness of the rocks. Despite the absence of maps, the crystalline core of the island, with its striking scenic contrasts, long ago attracted geologists, and has been again described, in all its picturesqueness, by Sir Archibald Geikie in our own day. We well remember the seductive map, on the scale of four miles to an inch, with which we ourselves tramped across the boggy grasslands, or wandered in midnight prodigality above the Sound of Sleat; and Mr. Harker complains that, even now, names and details are not always exactly placed on the sheets issued by the Ordnance Survey. The work that he has now done, and the manner of it, will be honoured by all who know the island.

The view that the crystalline central masses represent the core of the volcano from which the abundant plateau-basalts flowed appears to be now untenable, although some kind of a volcano, and a fairly large one, may have existed on the crown of the great laccolitic dome. Certain earlier volcanic vents, moreover, provide curious evidence that gabbro and granite existed, in a consolidated form, down below, while the plateau-basalts were being extruded. In a very remarkable passage (p. 24), the author shows that even the sequence of these rocks was the same as that now known to exist in the central laccolitic area. The acid tuffs of Skye containing granite (p. 20), the basic tuffs crowded with fragments of gabbro (p. 21), go far as evidence of the continuity of lava-types with holocrystalline representatives below. It is interesting to remember that, when Prof. Judd wrote his well known papers, this natural-history view of igneous masses was very far from general acceptance; and the fact that he strove for it so successfully has been obscured by the subsequent controversy as to the local sequence in the Hebrides.

Mr. Harker, in dealing with the basalt plateaux (pp. 29, 239, and 435), shows excellently how large a part is played by the abundant intrusive sills. These form, indeed, on weathering, most of the terraced structure that observers were formerly apt to attribute to successive lava-flows. It is remarkable (p. 12) that the dykes or vents can so rarely be traced into the lava-sheets to which they gave rise; but this is a common complaint in all areas of copious and long-continued activity. The temporary theory of fissure-

[1] "The Tertiary Igneous Rocks of Skye." By Alfred Harker, M.A., F.R.S., with notes by C. T. Clough, M.A., F.G.S. Pp. xii + 482. (Memoirs of the Geological Survey of the United Kingdom. Glasgow: Printed for His Majesty's Stationery Office by James Hedderwick and Sons, 1904.) Price 9s.

eruptions has been practically modified into that of eruption from a large number of small and easily concealed vents, which were doubtless situated along fissures; and this theory is borne out by observed occurrences along rifts on Etna. Mr. Harker himself points out (p. 14) that "the great thickness and extent of the basalt group results only from the superposition and overlapping of a vast number of separate flows, each of which is of very insignificant dimensions."

The small group of trachytes and rhyolites (p. 56) in Skye occurs clearly between two series of basalts, a fact very satisfactory for Irish geologists, who have had to maintain similar views for their acid lavas on less convincing evidence. Much of the interest of the petrographic details furnished by Mr. Harker lies in the attack of one rock on another. The dissection of an early peridotite by an overpowering mass of gabbro (p. 64), the occurrence of "xenoliths" of one kind of gabbro in another (p. 121), the mutual modifications of gabbro and granite in the Red Hills (p. 183), which are justly attributed to a process of diffusion, may be named as examples of the important problems dealt with. We confess to a personal interest in the results of Mr. Harker's researches on composite sills (p. 209), where an acid rock is shown to pick up fragments of an earlier basic one, and to discharge, as it were, its own porphyritic crystals into the latter along its margins. Such facts make us doubtful of the necessity for assuming a distinction between "segregation-veins," with ill-defined edges, and "ordinary veins of intrusion" (p. 78), or for the belief that bands, the crystals of which interlock at the common surface, "must have existed side by side in the fluid state" (p. 119). The discussion of the banded gabbros, with the beautiful plates accompanying it, forms a chapter of exceptional value, though it hardly does justice to Mr. Harker's own recent work, in which he has explained the genesis of a Cainozoic banded gneiss. The reference (p. 115) of the "pyroxene-granulites" of Skye to "altered representatives of basic lavas entangled in the gabbro complex" is in happy agreement with the most modern views as to similar rock-masses in the Saxon metamorphic area.

A local rock of hybrid origin is termed *marscoite* (pp. 175 and 192); this occurs as sills, and is regarded as a basic magma modified by the absorption of granitic material prior to its intrusion. Mr. Harker holds that such "hybrid rocks are essentially abnormal in composition"; yet it may be urged that in the deeper plutonic regions many rocks, which we have come to consider normal, have arisen by processes of admixture and diffusion. The junction of the granite and the Cambrian limestone in Skye (p. 135) presents evidence of solution of the limestone, without addition of lime to the granitic magma. We prefer to believe that a slow diffusion and transference of the lime occurred into the great subterranean mass, or that the locally modified granitic magma flowed on elsewhere, leaving new and unmodified material in contact with the limestone, rather than to conclude that a rock which absorbed gabbro and Torridon Sandstone behaved in a mysteriously different manner towards dolomitic limestone. The singular absence of veins passing from the granite into the limestone rather suggests rapidity of solution. But the case is certainly an uncommon one, as other contacts of these two rocks show. Down below us as we write, an ancient granite sends off zig-zag veins abundantly into the "Dalradian" limestone of Donegal; behind us, the same granite produces a coarse quartz-diorite, by interaction with a basic sill of the same series. A little south, at Summy Lough, the pre-Devonian gabbros have brought up inclusions of an earlier gabbro, which "weather into little hollows," like those of the corrie of Tairneilear. In the universality of the problems discussed by Mr. Harker lies their wide geological attraction; and we venture to think that many of his questions will receive their answer in more distinctively plutonic regions. For a long time, Continental geologists maintained that some fundamental difference separated our modern lavas from the crystalline masses revealed in older regions of the crust. Similarly, our fluidal gneisses, with their mutual interactions, have been held to be something primordial and apart. This purely mental barrier is now rapidly breaking down, and we may find that the phenomena so carefully set before us in the case of Skye have deep-seated and more impressive representatives in the floor of Saxony or Norway.

FIG. 1.—View of Sgurr nan Gillean. (From "The Tertiary Igneous Rocks of Skye."

Mr. Harker's book, with its handsome photographic illustrations, is published at a very moderate price, seeing that it appeals entirely to the professed geologist. Indeed, when dealing with so superb an area, we think that a little more descriptive power might have been used to unite the scenic and the petrographic features. We thus wish that chapter xxvi., on "physical features and scenery," had sent off intrusive sheets into those that went before it, and had even wrapped round much of their contents as literary "xenoliths." With the manner of the text we have little fault to find. It is always clear and direct—far clearer, in fact, than the explanatory diagram on p. 433. The Americans have given us many worse names than "mugearite"; and other authors beside Mr. Harker have written "amygdule" in place of the obvious "amygdale." "Phenocryst," like "cab" and "bus," must probably be accepted as a compromise, though we expect better things of scientific men; and the incorrect use of "granophyre," introduced by Rosenbusch, has become widely tolerated through repeated publication. The term "ophitic plates," rather than "ophitic crystals"

or "ophitic nodules," where augite or hornblende are concerned, has been sanctioned by microscopists, but tends to mislead when actual rock-specimens are examined. Beyond these trifling criticisms, we have nothing but praise for this conscientious exposition of results, behind which lies a vista of personal sacrifice and prolonged observation in the field.

GRENVILLE A. J. COLE.

ENGLISH MEDICINE IN THE ANGLO-SAXON TIMES.[1]

FROM an educational point of view, an acquaintance with the history of scientific discovery is even more important than a knowledge of the results of scientific investigation up to the most recent date. The latter knowledge is essential for progress, as it is for practical application of results already gained. The former is needful in order to understand the methods of science, to imbibe the spirit of discovery, to appreciate the reciprocal action of hypothesis and experiment, and to acquire the mental habit of looking with scientific eyes upon every branch of human knowledge.

The history of mathematics, of chemistry, of geology, and of the inductive sciences in general, has been adequately treated by many foreign and by some English writers. But one of the most ancient branches of knowledge has been sadly neglected in this country. The history of medicine as the science of disease, and of medicine as the art of prevention and cure, has been far more studied by French and German, Dutch and Italian physicians than by those who write in English. It is therefore a matter of congratulation that the College of Physicians, which dates from the wonderful re-birth of learning in the days of Sir Thomas More, of Dean Colet, of Erasmus, and of Linacre, should have been entrusted by the widow of a learned member, the late Dr. Fitz-Patrick, with the endowment of a lectureship on the history of medicine.

In this volume Dr. Payne treats with remarkable learning and interest of the art of medicine as it existed among our ancestors before the Conquest. For his purpose he has not the help of such inscriptions as describe and delineate the duties of physicians in the Babylonian and the Egyptian empires, nor the rich and wonderful collection of medical instruments which is preserved in the Museum of Naples. He has only literature to depend on.

English learning dates from Archbishop Theodore of Tarsus (A.D. 669), who, with the Abbot Adrian, founded a school at Canterbury, where Greek as well as Latin, arithmetic, and astronomy was, according to the testimony of the justly Venerable Bede, successfully taught. Bede himself wrote on astronomy, and was probably the author of a treatise "De phlebotomia." In his "Ecclesiastical History of Britain" he described several epidemics of the true oriental or bubonic plague. St. John of Beverley recorded a case of aphasia in a youth who was also affected with impetigo of the scalp, and was cured of both. Among the West Saxons in the ninth and tenth centuries literature flourished. Poetry, history, and religious works were written in native English as well as in Latin, and have been adequately studied by more than one German scholar. This civilisation, with its numerous schools and libraries, was interrupted by the disastrous inroads of the Danes; but up to the Conquest and beyond, notable works appeared, and some of these were treatises on medicine. Among others published by Cockayne nearly fifty years ago were "The Leech-Book" of Bald (written when Alfred was king, or soon after his death), a book of recipes and a glossary of the names of plants, of which the manuscript is preserved in the library of the Cathedral of Durham.

The following remarks by Dr. Payne deserve to be widely read, for their application is general:—

"Before speaking in detail of the old English medical books, I will venture to say a word about the spirit in which they should be studied. Too often, those few persons who have interested themselves in these monuments of ancient science have treated them in one of two ways. Either they have picked out something especially unlike the ways of modern thought, and held it up to scorn as showing the folly of our ancestors, or else in kinder mood they have condescended to be amused, and calling anything old and unfamiliar 'quaint,' dismissed it with a smile. Neither of these methods will help us to understand the ancient world. The folly of our ancestors is no explanation. Their knowledge was no doubt extremely limited; they saw old and distant things through a dense and prevailing fog of ignorance. But that they tried to understand them at all is a proof of their wisdom, not of their folly.

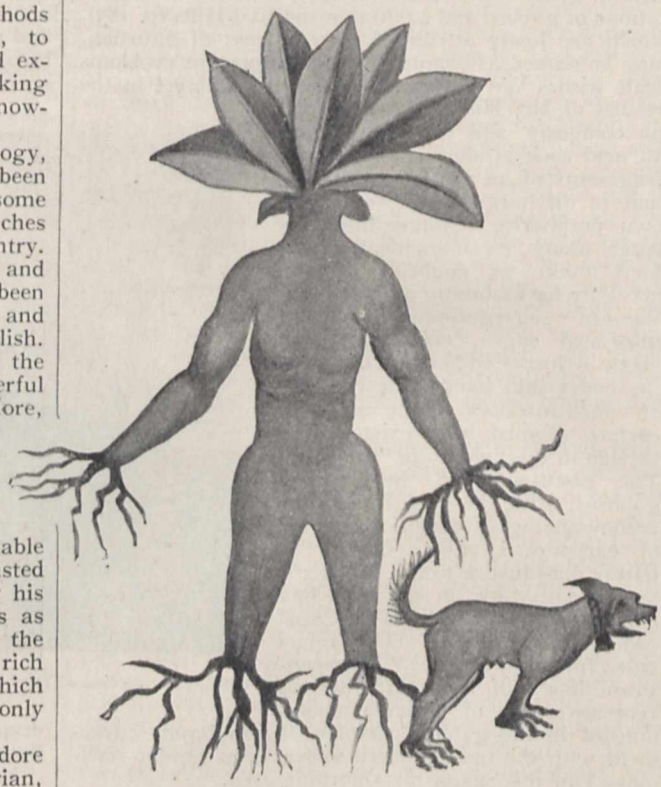


FIG. 1.—Mandragora, Mandrake, with the dog used to put it up. A simple and probably early form of the legend. (From "The Fitz-Patrick Lectures for 1903.")

"Still more misleading is the habit of regarding the rude features of primitive art, the stammering words of an infant literature, the childish fallacies of early science, as something to be amused at. Till we have got beyond the stage of calling these old things merely 'quaint,' there is no possibility of understanding them at all. Therefore, if we quote from the old books things which appear strange in our eyes, foolish things if you like, it is not with the object of raising

[1] *The Fitz-Patrick Lectures for* 1903. By Joseph Frank Payne, M.D. Oxon., Fellow and Harveian Librarian of the Royal College of Physicians, Consulting Physician to St. Thomas's Hospital. Pp. 162; with twenty-three illustrations from early English MSS. (Clarendon Press.) Price 8*s.* 6*d.* net.

a laugh or of flattering the modern sense of superiority. The only way to understand these old writers is to try to put ourselves as far as possible in their place, and conceive how nature and science presented themselves to the eyes of the early teachers and learners in the tenth and eleventh centuries."

A full account is given of the mythical "mandrake," with several instructive drawings from Anglo-Saxon manuscripts (see Fig. 1), and others of plants which can be recognised as characteristic, while some are gracefully conventional. Many drawings of foreign plants are copied from more original sketches, until they have become mere ornamental designs. These figures may be compared with the beautiful drawings published by Prof. Haeckel of animal structures adapted to suggest the decorative use of countless organic forms to carry on the conventional lines of Greek architects and Italian decorators.

An interesting section of Dr. Payne's volume is devoted to the old English names of plants. "Waybroad" has been ill exchanged for the so-called plantain, and "maythe" for camomile. On the whole, he agrees with Prof. Earle that there was a great decadence in botanical knowledge in England between the eleventh and sixteenth centuries.

The practice of surgery by the Anglo-Saxon leeches was for the most part confined to the external application of divers vegetable or animal concoctions which can have been only negatively useful. Some of them remind us of Alexis of Piedmont, who, after describing an unfailing remedy, adds, "If this will not do it, take this other." Here and there we come across curious anticipations of modern pathology and surgery, *e.g.* when we are told that if the insensible hardening of the liver is of too long duration, then it forms a dropsy which cannot be cured; or when the plastic operation for hare-lip is described. Amputation for gangrene of a limb is also recommended.

The last sixty pages are devoted to superstitious treatment by amulets and charms, some derived from Greek treatises, as they in their turn reproduced the magical lore of Egypt and of Babylon. One extract, however, from a sermon of St. Eligius, who furnished the gentle abbess of the "Canterbury Tales" with her only oath, might still be preached from English pulpits against the quackery and miscalled Christian science of the present day. If space permitted, it would be interesting to refer to Dr. Payne's comparison between the "Practica" of the famous school of Salernum and the old English "Leech-book," and to his account of the final decay of the native art of medicine and its replacement by the less vigorous and less original doctrines of Continental Europe in the later Middle Ages.

The work is of great value and interest not only to physicians, but to scholars, antiquarians, and philologists. It is admirably printed and illustrated, and will, we hope, be succeeded by the publication of future lectures by the same accomplished physician.

NOTES.

THE *Atti dei Lincei* announces the death on August 19 of Prof. Emilio Villari, recently president of the Reale Accademia dei Lincei.

MR. C. FOX-STRANGWAYS, who joined the staff of the Geological Survey in 1867, has retired from the public service.

AN earthquake shock was felt in the Cowall district of Argyllshire shortly after 4 a.m. on September 18. In Dunoon the shock was most distinctly felt. Dishes rattled, doors were opened, bells were set ringing, and ornaments were broken.

REUTER reports that two distinct shocks of earthquake were felt at Ottawa at 7.53 p.m. on September 14. The first lasted five seconds, and after an intermission of three seconds came the second shock, which was of six seconds' duration. The direction was from south-west to north-east.

A CONGRESS of free thought was opened at Rome on Tuesday in the Grand Court of the Roman College. Prof. Sergi, president of the committee, welcomed the members of the congress, and the following were elected honorary presidents:—Prof. Haeckel (Germany), M. Berthelot (France), Dr. Maudsley (Great Britain), Señor Salmeron (Spain), M. Novimoff (Russia), Herr Bjoersen (Norway), and Prof. Lombroso (Italy).

AT the St. Louis Exhibition a steel tower 300 feet high has been erected for wireless telegraphy by Dr. De Forest and his coadjutors, and communication has been established between St. Louis and Chicago. We learn from the *Times* that the United States Government is also exhibiting a working De Forest station, and there are seven working exhibits in the exhibition. The United States Government has contracted with the De Forest Company for five long-distance stations at Key West, Pensacola, Puertorico, South Cuba, and Panama. The longest distance between these stations will be 1000 miles, which will far exceed the distance attempted for wireless telegraphy by any Government before.

IT is announced that the high-level observatory on Ben Nevis will be closed next month. The annual cost of the double observatory, high- and low-level, is close on 1000*l.*; of this sum about three-fourths is spent on the high-level and about one-fourth on the low-level station. The Treasury has offered to pay direct to the Scottish Meteorological Society on behalf of the Ben Nevis Observatory the 350*l.* recommended by the committee of inquiry into the administration of the Parliamentary grant for meteorology, instead of making this sum a charge on the meteorological grant. The continuance of the observatories could, however, only be undertaken on a guaranteed income of 1000*l.* a year. The directors have therefore decided to close the observatories.

THE New York correspondent of the *Daily Chronicle* announces that Commander Peary will lead another expedition to the North Pole next year. The expedition will start in the summer, and will be gone probably not longer than two years. Its expenses are estimated at 30,000*l.*, which is 10,000*l.* more than the last Peary Expedition cost. American capitalists are supplying the funds. A vessel is now being built which, it is said, will be stronger and more suitable to the conditions prevailing in the Polar regons than any previous ship. One part of her equipment will be an ice-breaker bow, which is expected to enable the ship to break through to a point farther north than has hitherto been reached. The features of the expedition will be the fixing of a base within 500 miles of the Pole, the use of very light sledges and fast Esquimaux dogs to make a final dash for the Pole, and the adoption of conditions of living corresponding as nearly as possible to those of the Esquimaux themselves.

THE expedition, on board the steamer *Frithjof*, which took out a supply of coal for the Ziegler North Polar Expedition, whose ship, the *America*, left for the Arctic regions nearly fifteen months ago, has returned to Norway without having communicated with the *America*. This is the second attempt which has been made this year by the relief expedition to reach Franz Josef Land, but on each occasion the severity of the weather, together with fog and ice, has

compelled the *Frithjof* to return; and now it is impossible that another attempt can be made until next year. There has been no news of the *America* since she left Norway in July, 1903, but, so far as can be ascertained, it was intended that on reaching Franz Josef Land the explorers should establish a supply base, from which forced marches would be made in the direction of the Pole. No apprehension is felt concerning the *America*, for the ship carried provisions for five years, and there are also stores of pemmican and clothes available.

SCIENTIFIC critics in Berlin are now much exercised with regard to the remarkable performances of "Clever Hans," the thinking horse. According to the daily Press, a representative committee, which included the director of the Berlin Zoological Gardens, a veterinary surgeon, and a professor of the Physiological Institute of the Berlin University, witnessed these performances with the view of ascertaining whether they were the result of a trick, or whether they were due to the mental powers of the animal. Their verdict, it is reported, was unanimous in favour of the latter view. It is stated that when told that the day was Tuesday, and asked which day of the week this represented, the horse would give the correct answer by taps. Similarly he will tell not only the hour, but the minutes indicated by a watch; while he is also reported to be able to record the number of men and of women among a row of visitors, and to indicate the tallest and the shortest members of the party.

IT is stated in the *Times* that Messrs. C. G. Spencer and Sons, of Highbury, have lately constructed, from the designs of Señor Alvares, a new aëroplane flying machine which does away with the gas vessel and its many risks. The structure consists of two swing-like aëroplanes having a superficial area of 400 square feet; these are attached to two outstretching and slightly curved arms and fixed to a bamboo framework, in shape like a cigar. In the front of this framework is fitted a 2 horse-power motor, which drives two two-bladed tractors—each of them 5 feet in diameter—which are placed one on each side of the frame, and level with the motor. At the back of the machine are three rudders, which are worked from the front by means of ropes. Two of the rudders are triangular, and are constructed to move horizontally, for the purpose of controlling the upward and downward motion of the machine, while the other, the largest of the three, which is rectangular, is fitted perpendicularly, and is intended to guide the machine to the left or right. The weight of the machine is 150 lb. without the aëronaut. It does not appear that the invention has any power of raising itself from the ground, as it is stated that during the next few days it is to be taken up by a balloon, at the Crystal Palace, to an altitude of 5000 feet, when it will be released for the purpose of testing its actual power of flight.

SIR LOWTHIAN BELL was elected president of the Institution of Mining Engineers for the ensuing year at the meeting held at Birmingham last week. A paper by Prof. Redmayne read before the meeting is summarised on p. 524. Among other papers read was one by Mr. George Farmer, on the problem of gob-fires, in the course of which he pointed out that coal absorbs oxygen quickly, and more quickly as the surface open to oxidation increases and as the heat increases, so that any cause which will split up the gob-material will aid in initiating a fire. Moisture assists the oxidation and heating by splitting up the gob-material, so that this may be considered an important factor. In every case in which a fire has been properly located props left in the goaf, or ribs of coal left against faults, or falls in working stalls burying a rib of coal, have been found to be the origin. In any method of extinction means must be taken for cooling the hot material by the application of substances which will absorb the heat and reduce the temperature to such a degree that combustion entirely ceases in a natural atmosphere, or by the removal of the combustible material from the influence of the heat. Mr. J. Cresswell-Roscamp described an improved apparatus for laying dust in coal mines. Water (or other liquid) is forced by pumps into an air-cylinder, which causes a regular and unpulsating column to flow along the pipes and out of sprayers or nozzles fitted with a specially constructed screw apparatus round which the liquid is forced, so as to cause the spray to spread over a circular breadth up to 30 feet. The sprays are in the shape of inverted cones impinging on each other, and become broken up into extremely fine particles, which are carried along by the air current and can clearly be felt from 100 feet to 150 feet behind the apparatus when in motion.

IN the year 1883 the late Sir Cuthbert Peek established an important meteorological station at Rousdon, Devon, midway between Lyme Regis and Seaton, and from time to time various self-recording instruments, including a Dines's pressure tube anemometer, have been added. The observations have been regularly continued under the superintendence of the Hon. Lady Peek, and we have received a copy of the results for the year 1903. As this volume completes a period of twenty years, tables are appended giving the average monthly and annual results for the years 1884–93. The observatory is a second order station of the Royal Meteorological Society, and the work is a valuable contribution to the climatology of the south of England.

WE have received the report of the U.S. Weather Bureau for 1902–3. The first part of this elaborate compilation, containing a very interesting account of the administrative work of the year, was referred to in our issue of February 4 (vol. lxix. p. 328). The remaining portions consist of meteorological summaries, including hourly averages from the records of automatic instruments at twenty-eight stations, and monthly and annual means at stations in the United States and West Indies. Among the many valuable miscellaneous tables and reports we may mention especially those showing the accumulated amounts of precipitation for each five minutes at stations in the United States and West Indies supplied with automatic gauges, during all storms in which the rate of fall equalled 0·25 inch in five minutes or 0·75 inch in one hour. The volume also contains hourly observations at several localities in the West Indies; these are of importance in connection with the study of the destructive hurricanes which frequently occur in those regions.

IT may be of interest to some of our readers to know that very complete meteorological observations, taken three times a day at the Central Meteorological Office at Vienna, together with daily and monthly means, are regularly published in the *Anzeiger* of the Vienna Academy of Sciences. Further, that the observations for each month are followed by the observations made in connection with the international scientific balloon ascents. We have before us the results of two ascents of manned and one of unmanned balloons in the month of June last. In addition to the summary of the principal facts obtained during the ascents, the actual observations taken every few minutes and explanatory remarks are given. The publication of these valuable data so soon after their occurrence is of considerable importance for the study of the processes at work in the upper strata

of the atmosphere, in connection with weather recently experienced.

THE Biological Survey of the U.S. Department of Agriculture has issued a *Circular* (No. 44) giving the names and addresses of officials connected with the preservation of birds and game in the United States and Canada.

WE have received Nos. 17 and 18 of vol. xlviii. of the *Memoirs* of the Manchester Literary and Philosophical Society. In the latter Dr. Hoyle gives a diagnostic key to the recent genera of dibranchiate cephalopods. In the former Prof. Dawkins describes a molar of the straight-tusked elephant (*Elephas antiquus*) from glacial strata at Blackpool. Apropos of fossil elephants, it may be mentioned that a few days ago workmen disentombed in a sand-pit at Erith an entire skull of a mammoth, which fell to pieces when brought to the surface. This is much to be regretted, as the specimen might doubtless have been saved had palæontologists been informed of the discovery before attempts were made to remove it from the bed.

THE August number of the *Brooklyn Edison*, published by the Edison Electric Illuminating Co., of Brooklyn, New York, contains several striking pictures of decorative and spectacular electric lighting at Coney Island, one of which, from a photograph taken at night, is here reproduced. Within a year the amount of electric illumination at this famous pleasure resort has more than trebled; and probably

FIG. 1.—Luna Park, Coney Island, showing the magnitude and extent of the electric illumination. From a photograph taken at night.

there is not now to be found anywhere in the world a place where the decorative possibilities of the electric incandescent lamp are so strikingly demonstrated. The Brooklyn Edison Co., which has successfully carried out the scheme of lighting at Coney Island, supplies light and power to an area of seventy-seven square miles and a population of nearly one and a half millions.

AN important discovery in connection with cotton-growing in the southern United States is recorded in *Bulletin* No. 49 of the Entomological Division of the U.S. Department of Agriculture. It appears that an ant has been discovered in Guatemala which preys on the adult cotton boll-weevil (*Anthonomus grandis*) and thus checks the ravages of this insect, and so permits the growing of cotton in districts where it would otherwise be impossible. It has been found that the kelep, as the ant is called in Guatemala, can be easily removed, and colonies have accordingly been introduced into the cotton plantations of Texas in the hope of checking the devastation caused by the weevil. It only remains to ascertain whether the kelep will be able to withstand the winter climate of Texas.

THE last published part of *Biometrika* contains a valuable paper by Dr. H. E. Crampton demonstrating the existence of natural selection during the pupal stage of *Philosamia cynthia*, a silk-producing moth. Dr. Crampton's observations differ from the experiments conducted by Prof. E. B. Poulton, Mr. F. Merrifield, and Miss C. Sanders in the fact that his pupæ were not exposed to the attacks of enemies; so that the elimination, which took place on a large scale, must presumably have been due to internal rather than external causes. In the author's opinion, the actual basis for selection in this particular instance is not use-advantage, but correlation. Prof. Pearson's important Huxley lecture on the inheritance of the mental and moral characters in man has been already noticed in the pages of NATURE. An elaborate memoir, illustrated by a very fine series of photographs, on the variation and correlation of the human skull, is contributed by Dr. W. R. Macdonell. The material discussed is the splendid series of skulls discovered some eleven years ago in Whitechapel, and now in the possession of Prof. Thane. Dr. Macdonell concludes that these crania, which date most probably from the time of the Great Plague, are in general appearance and biometric constants remarkably close to the Long Barrow British. As the result of an investigation on inheritance of coat-colour in the greyhound, A. Barrington, A. Lee, and K. Pearson conclude that the ancestral law of decreasing correlation holds no less for their present material than for man and horse. Prof. Weldon's research on the form of the shell spiral in a race of *Clausilia itala* failed to disclose the existence of any selective elimination between the young and the adult stage; reasons for this result are suggested. The number ends with an elementary proof of Sheppard's formulæ, with which are associated certain other formulæ for dealing with the ordinates and adjacent areas of frequency curves.

THOUGH graphical work is now rightly regarded as an essential part of an elementary course of mathematics, many teachers are still unfamiliar with the new methods, and do not comprehend clearly all that is implied in graphs. The "Solutions of the Examples in Hall's 'Graphical Algebra,'" by Mr. H. S. Hall, assisted by Mr. H. C. Beaven, just published by Messrs. Macmillan and Co., Ltd., will be of great service to those teachers and students to whom graphical methods are novel, in showing how problems may be easily and accurately solved by plotting graphs. The book will assist the introduction and extension of graphical methods in mathematical classes.

A CATALOGUE of apparatus for electric heating and cooking just issued by Messrs. Isenthal and Co., 85 Mortimer Street, London, W., contains particulars of many attractive ways in which electricity is used for heating purposes. The advantages of electric heating from a hygienic point of view are obvious; and, economically, the consumption of electric energy is not so excessive as is usually assumed. Messrs. Isenthal's list includes radiators of various types, ornamental stoves, cooking ranges and ovens, appliances for heating and boiling liquids, hot water geysers and cisterns, sterilisers, soldering bits, hot plates for chemical laboratories or photographic purposes, evaporators, and numerous other devices which would add to the comfort and cleanliness of many operations in laboratories as well as in houses. The adaptability of the electric current, and the efficiency of the various forms of apparatus described in Messrs. Isenthal's catalogue, should encourage the use of electric energy as a source of heat.

IN the August number of the *Gazzetta* E. Paternò and E. Pannain have established that, under certain conditions, electrolysis converts potassium cyanide in aqueous solution containing potash completely into cyanate. The latter separates during the electrolysis in a pure state in the form of white crystals.

ACCORDING to a brief report by J. Stěp, director of the Joachimsthal Mine, published in the *Proceedings* of the Vienna Academy of Sciences (No. 14), freshly excavated uranium ore, which has never been exposed to the light, is strongly radio-active. A comparative study of the activity of illuminated and unilluminated specimens of the ore has yet to be made.

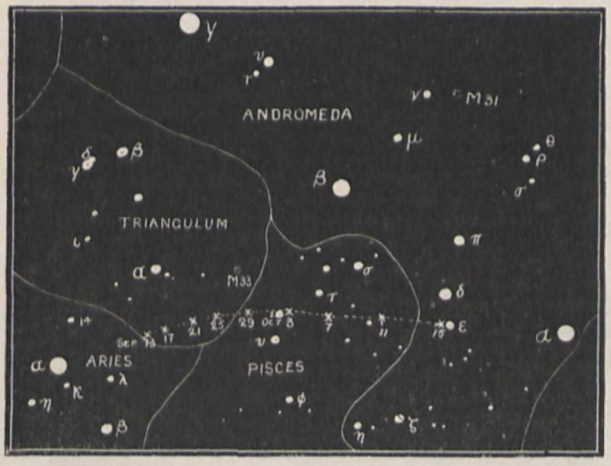
IN vol. vii. of the *Fortschritte auf dem Gebiete der Röntgenstrahlen* Dr. Josef Rosenthal discusses the relative advantages of large and small induction coils for producing X-rays. When the tube used is not too highly exhausted, and consequently has not too great a resistance, a small coil giving a comparatively short spark may be used with good results. Small coils have, moreover, the advantage of being more portable and less costly than large coils. But when a tube with a high vacuum is used a higher tension coil has to be employed, and in such cases, in order to prevent the tube from changing during a long exposure, the number of interruptions per second must be reduced as much as possible.

OUR ASTRONOMICAL COLUMN.

THE RETURN OF ENCKE'S COMET (1904 *b*).—As announced in these columns last week, Encke's comet was re-discovered at Koenigstuhl-Heidelberg on September 11.

It was found by Herr Kopff, who describes it as being, at present, a faint object. According to a note by Mr. Denning, however, mentioned in NATURE for July 21, the favourable conditions of 1805, 1838, and 1871 should be repeated during the present apparition, and it is possible that the comet may become visible to the naked eye when near to Altair, early in December.

The accompanying chart given below shows, approximately, the apparent path of the comet among the stars from now until October 15, according to the daily ephemeris published by MM. Kaminsky and Ocoulitsch in No. 3962 of the *Astronomische Nachrichten*:—



VARIATIONS IN THE LUNAR LANDSCAPE.—A communication from Harvard reports that Prof. W. H. Pickering, at present located at the Lowe Observatory, California, observed a bright hazy object 2″ in diameter upon the floor of the lunar crater Plato on July 31. Six previous observations made between July 21–28 inclusive gave no indication of this novel feature.

On August 2 a black elliptical shadow two miles in diameter was seen in the place of the previously observed bright spot, whilst to the north-east and north there extended a large white area, the existence of which was confirmed by an observation made on August 3.

A telegram dated August 22 states that real conspicuous changes have taken place in this region during the past month, and confirms the existence of the new crater, which has a diameter of about three miles. The bright area has shifted considerably since August 3.

Several other objects which have not been mapped before were observed whilst examining Plato, and it was seen that the previously conspicuous white area surrounding craterlet No. 54 (Harvard College Observatory *Annals*, vol. xxxii., plate x.) has now disappeared.

SUN-SPOT PERIODICITY AND TERRESTRIAL PHENOMENA.—In a brochure published at Rochechouart (1904), Prof. O'Reilly, of Dublin, emphasises the important part which a knowledge of the periodicity of solar activity plays in the prediction of terrestrial meteorological events, and also demonstrates that the origins of several important historical events may possibly be attributed to the meteorological effects of solar changes.

After discussing the more recent droughts, such as have caused distress in Australia and India, and showing that these occurred at definite epochs of solar cycles, he shows that the successive floods which caused the formation of the Zuyder Zee probably occurred at epochs of sun-spot maxima. Similarly he points out that each of the ten centuries in Etruscan chronology were approximately 122·2 (*i.e.* 11·11×11, or nearly 11^2) years in length, that is to say, they contained about eleven sun-spot periods, and he supposes that the Etruscan era probably commenced from a period of great cold, or maybe some memorable flood, which could be attributed to excessive solar activity.

From a study of Brückner's sun-spot cycles, Prof. O'Reilly believes that the year 1895 was the culminating year of a period of heat and drought, and that 1915 will be the corresponding centre-year of a period of cold and rain.

OBSERVATIONS OF THE RECENT PERSEID SHOWER.—M. Henri Perrotin, observing at Nice, saw 1184 meteors, of which 1041 were Perseids, during the nights of August 9–14 inclusive. The observations were made between the hours of 8 p.m. and 3 a.m. each night at the meteorological station of the Nice Observatory, situated at an altitude of 2740 metres on Mount Mounier.

The Perseids, as shown in his tabulated results, were very numerous, the maximum display of the shower occurring on the night of August 11–12, especially between 1 a.m. and 3 a.m. The maximum for each night occurred between midnight and 3 a.m.

A notable feature of the display was that the meteors appeared in groups of two or more, each group being followed by a break five to fifteen minutes in length.

The radiant of the shower was seen to be a fairly extensive area, not a point, having its centre near to γ Persei.

The Perseids were white and very swift, whilst the paths were comparatively short. On the other hand, the sporadic meteors observed were of a reddish-yellow colour, their paths were long, and they travelled slowly, leaving trails which lasted for some seconds.

These observations again emphasised the importance of selecting a station situated at a high altitude where the atmosphere is generally exceptionally clear (*Comptes rendus*, No. 9, 1904).

RADIATION IN THE SOLAR SYSTEM.[1]

I PROPOSE to discuss this afternoon certain effects of the energy which is continuously pouring out from the sun on all sides with the speed of light, the energy which we call sunlight when we enjoy the brilliance of a cloudless sky, which we call heat when we bask in its warmth, the stream of radiation which supports all life on our globe and is the source of all our energy.

As we all know, this ceaseless stream of energy is a form of wave motion. If we pass a beam of sunlight, or its equivalent, the beam from an electric arc, through a prism, the disturbance is analysed into a spectrum of colours, each colour of a different wave-length, the length of wave changing as we go down the spectrum from, say, 1/30,000 inch in the red to 1/80,000 of an inch in the blue or violet.

But this visible spectrum is merely the part of the stream of radiation which affects the eye. Beyond the violet are

[1] Afternoon address delivered at the Cambridge meeting of the British Association, August 23, by Prof. J. H. Poynting, F.R.S.

the still shorter waves which affect a photographic plate or a fluorescent screen, and will pass through certain substances opaque to ordinary light. Here, for instance, is a filter devised by Prof. Wood which stops visible rays, but allows the shorter invisible waves to pass and excite the fluorescence of a platinocyanide screen.

Again, beyond the red end are still longer waves, which are present in very considerable amount, and can be rendered evident by their heating effect. We can easily filter out the visible rays and still leave these long waves in the beam by passing it through a thin sheet of vulcanite. A piece of phosphorus placed at the focus of these invisible rays is at once fired, or a thermometer quickly rises in temperature. The waves which have been observed and studied up to the present time range over some nine octaves, from the long waves described to the section yesterday by Prof. Rubens, waves of which there are only 400 in an inch, down to the short waves found by Schumann in the radiation given off by hydrogen under the influence of the electric discharge, waves of which there are a quarter of a million in an inch. No doubt the range will be extended.

Radiant energy consists of a mixture of any or all of these wave-lengths, but the eye is only sensitive at the most to a little more than one octave in the nine or more.

This radiation is emitted not only by incandescent bodies such as the sun, the electric arc, or flames. All bodies are pouring out radiant energy, however hot or cold they may be. In this room we see things by the radiation which they reflect from the daylight. But besides this borrowed radiation, every surface in the room is sending out radiation of its own. Energy is pouring forth from walls, ceiling, floor, rushing about with the speed of light, striking against the opposite surfaces, and being reflected, scattered, and absorbed. And though this radiation does not affect our eyes, it is of the utmost importance in keeping us warm. Could it be stopped, we should soon be driven out by the intense cold, or remain to be frozen to death.

As the temperature of a body is raised, the stream of radiation it pours out increases in quantity. But it also changes in quality. Probably the surface always sends out waves of all lengths from the longest to the shortest, but at first when it is cold the long waves alone are appreciable. As it gets hotter, though all the waves become more intense, the shorter ones increase most in intensity, and ultimately they become so prominent that they affect our sense of sight, and then we say that the body is red or white hot.

The quality of the stream depends on the nature of the surface, some surfaces sending out more than others at the same temperature. But the stream is the greatest from a surface which is, when cold, quite black. Its blackness means that it entirely absorbs whatever radiation falls upon it, and such a surface, when heated, sends out radiation of every kind, and for a given temperature each kind of radiation is present to the full extent, that is, no surface sends out more of a given wave-length than a black surface at a given temperature.

A very simple experiment shows that a black surface is a better radiator, or pours out more energy when hot, than a surface which does not absorb fully, but reflects much of the radiation which falls upon it. If a platinum foil with some black marks on it be heated to redness, the marks, black when cold, are much brighter than the surrounding metal when hot; they are, in fact, pouring out much more visible radiation than the metal.

It is with these black surfaces that I am concerned to-day. But, inasmuch as it seems absurd to call them black when they are white hot, I prefer to call them full radiators, since they radiate more fully than any others.

For a long time past experiments have been made to seek a law connecting the radiation or energy flow from a black or fully radiating surface with its temperature. But it was only twenty-five years ago that a law was suggested by Stefan which agrees at all satisfactorily with experiment. This law is that the stream of energy is proportional to the fourth power of the temperature, reckoned from the absolute zero 273° below freezing point on the centigrade scale. This suggestion of Stefan served as the starting point of new and most fertile researches, both theoretical and practical, and we are glad to welcome to this meeting Profs. Wien, Lummer, and Rubens, who have all done most brilliant work on the subject.

Among the researches on radiation recently carried out is one by Kurlbaum in which he determined the actual amount of energy issuing from the black or fully radiating surface per second at 100° C., and therefore at any temperature.

Here is a table which gives the amount at various temperatures, as determined by Kurlbaum :—

Rate of Flow of Energy from 1 sq. cm. of Fully Radiating or "Black" Surface.

Absolute Temperature	Calories Grams of water heated 1° per sec.
0°	0·0
100° Air boils	0·000127
300° Earth's surface	0·0103
1000° Red heat	1·27
3000° Arc carbon	103
6000°	1650
6250°	1930

As an illustration of the "fourth power law," let us see what value it will give us for the temperature of the sun, assuming that he is a full radiator, or that his surface, if cooled down, would be quite black.

We can measure approximately the stream of energy which the sun is pouring out by intercepting the beam falling on a surface exposed to full sunlight, measuring the heat given to that surface per second, and then calculating what fraction the beam is of the whole stream issuing from the sun.

This was first done by Pouillet, and his method will serve to illustrate the principle of all other methods.

In his apparatus the sunlight fell full on a box containing water, and the rate at which the water rose in temperature gave the energy in the stream of solar radiation falling on the box.

Simple as the experiment appears, the determination is beset with difficulties, the chief being the estimation of the fraction of the energy intercepted by the atmosphere, and we are still unable to give a very definite value. Indeed, we cannot yet say whether the outflow of energy is constant or whether it varies. In all probability, however, it does vary, and Prof. Langley, who has devoted years of work to the subject, has recently obtained evidence indicating quite considerable variation.

We may, however, assume that we are not very far from the true value if we say that the stream of radiation from the sun falling perpendicularly on 1 sq. cm. outside the earth's atmosphere will heat 1 gm. of water 1/24° C. every second, or will give 1/24 calory per sec.

Now the area of a sphere round the sun at the distance of the earth is 46,000 times the area of the sun's surface. The energy from 1 sq. cm. of the sun thus passes through 46,000 sq. cm. at the surface of the earth. It is therefore 46,000 × 1/24 calories, or 1920 cal./sec. But from the table already given, a black surface at 6250° absolute, say 6000° C., gives 1930 calories per second, or the temperature of the sun's radiating surface is 6000°—if he is a full radiator, and there is good reason to suppose that no great error is made in taking him to be one.

Let us now take another illustration of the fourth power law.

Imagine a little black body which is a good conductor of heat placed in full sunlight at the distance of the earth. Let it be 1 sq. cm. in cross section, so that it is receiving 1/24 calory per second.

It will soon warm up to such a temperature that it gives out just as much as it receives, and since it is so small, heat will rapidly flow through it from side to side, so that it will all be very nearly at the same temperature. A sphere 1 sq. cm. in cross section has area 4 sq. cm., so that it must be giving out from each sq. cm. of its surface 1/96 = 0·0104 calory each second. From the table above it will be seen that this corresponds very nearly indeed to a temperature of 300° absolute or 27° C., say 70° F.

It is to be noted that this only applies to a little round body. A flat plate facing the sun would be about 60° C.

hotter, while if it were edgewise to the sun it might be very much colder.

Let us now see what would be the temperature of the small black sphere at other distances from the sun. It is easily seen that, inasmuch as the heat received, and therefore that given out, varies inversely as the square of the distance, the temperature, by the fourth power law, will vary inversely as the square root of the distance.

Here is a table of temperatures of small black spheres due to solar radiation :—

Distance from Sun's centre	Temperature Centigrade
3¾ million miles	1200° C. Cast iron melts.
23 million miles	327° Lead nearly melts.
At Mercury's distance	210° Tin nearly melts.
At Venus's distance	85° Alcohol boils freely.
At Earth's distance	27° Warm summer day.
At Mars's distance	−30° Arctic cold.
At Neptune's distance	−219° Nitrogen frozen.

We see from this table that the temperature at the earth's distance is remarkably near the average temperature of the earth's surface, which is usually estimated as about 16° C. or 60° F. This can hardly be regarded as a mere coincidence. The surface of the earth receives, we know, an amount of heat from the inside almost infinitesimal compared with that which it receives from the sun, and on the sun, therefore, we depend for our temperature. The earth acquires such a temperature, in fact, that it radiates out what it receives from the sun. The earth is far too great for the distribution of heat by conduction to play any serious part in equalising the temperature of different regions. But the rotation about its axis secures nearly uniform temperature in a given latitude, and the movements of the atmosphere tend to equalise temperatures in different latitudes. Hence we should expect the earth to have, on the average, nearly the temperature of the small black body at the same distance, slightly less because it reflects some of the solar radiation, and we find that it is, in fact, some 10° less.

Prof. Wien was the first to point out that the temperature of the earth has nearly the value which we should expect from the fourth power law.

Here is a table showing the average temperatures of the surfaces of the first four planets on the supposition that they are earth-like in all their conditions :—

Table of Temperatures of Earth-like Planets.

Mercury	196° C.
Venus	79° ,,
Earth	17° ,,
Mars	−38° ,,

The most interesting case is that of Mars. He has, we know, a day nearly the same in length as ours; his axis is inclined to the ecliptic only a little more than ours, and he has some kind of atmosphere. It is exceedingly difficult to suppose, then, that his average temperature can differ much from −38° C. His atmosphere may be less protective, so that his day temperature may be higher, but then to compensate, his night temperature will be lower. Even his highest equatorial temperature cannot be much higher than the average. On certain suppositions I find that it is still 20° below the freezing point, and until some new conditions can be pointed out which enable him to establish far higher temperatures than the earth would have at the same distance, it is hard to believe that he can have polar caps of frozen water melting to liquid in his summer and filling rivers or canals. Unless he is very different from the earth, his whole surface is below the freezing point.

Let us now turn from these temperature effects of radiation to another class of effects, those due to pressure.

More than thirty years ago Clerk Maxwell showed that on his electromagnetic theory of light, light and all radiation like light should press against any surface on which it falls. There should also be a pressure back against any surface from which radiation is reflected or from which it is issuing as a source, the value in every case being equal to the energy in a cubic centimetre of the stream. The existence of this pressure was fully demonstrated independently by Lebedew and by Nichols and Hull some years ago in brilliant experiments in which they allowed a beam of light to fall on a suspended disc in a vacuum. The disc was repelled, and they measured the repulsion and found it to be about that required by Maxwell's theory. Nichols and Hull have since repeated the experiment with greater exactness, and there is now no doubt that the pressure exists and that it has Maxwell's value.

The radiation, then, poured out by the sun is not only a stream of energy. It is also, as it were, a stream of pressure pressing out the heavenly bodies on which it falls. Since the stream thins out as it diverges, according to the inverse square of the distance, the pressure on a given surface falls off according to the same law. We know the energy in a cubic centimetre of sunlight at the distance of the earth, since, moving with the velocity of light, it will supply 1/24 calory per second. It is easy to calculate that it will press with a force of 6×10^{-5} degree on a square centimetre, an amount so small that on the whole earth it is but 70,000 tons, a mere trifle compared with the three million billion tons with which the sun pulls the earth by his gravitation.

But now notice the remarkable effect of size on the relation between the radiation pressure and the gravitative pull. One is on the surface and proportional to the surface, while the other penetrates the surface and pulls every grain of matter throughout the whole volume.

Suppose we could divide the earth up into eight equal globes. Each would have half the diameter of the earth and a quarter the surface. The eight would expose twice the surface which the earth exposes, and the total radiation pressure would be doubled, while the total gravitative pull would be the same as before. Now divide up each of the eight into eight more equal globes. Again the radiation pressure would be doubled, while gravitation would be the same.

Continue the process, and it is evident that by successive division we should at last arrive at globes so small and with total surfaces so great that the pressure of the radiation would balance the pull of gravitation. Mere arithmetic shows that this balance would occur when the earth was divided up into little spheres each 1/40,000 cm. in diameter.

In other words, a little speck 1/40,000 cm., say 1/100,000 of an inch in diameter, and of density equal to that of the earth, would be neither attracted nor repelled by the sun.

This balance would hold at all distances, since both would vary in the same way with the distance. Our arithmetic comes to this: that if the earth were spread out in a thin spherical shell with radius about four times the distance of Neptune, the repulsion of sunlight falling on it would balance the inward pull by the sun, and it would have no tendency to contract.

With further division repulsion would exceed attraction, and the particles would be driven away. But I must here say that the law of repulsion does not hold down to such fine division. The repulsion is somewhat less than we have calculated owing to the diffraction of the light.

Some very suggestive speculations with regard to comets' tails have arisen from these considerations, and to these Prof. Boys directed the attention of Section A last year. We may imagine that the nucleus of a comet consists of small meteorites. When these come near the sun they are heated and explosions occur, and fine dust is produced not previously present. If the dust is sufficiently fine, radiation may overpower gravitation and drive it away from the sun, and we may have a manifestation of this expelled dust in the tail of the comet.

I do not, however, want to dwell on this to-day, but to look at the subject in another way.

Let us again introduce our small black sphere, and let us make it 1 sq. cm. in cross section, 1·13 cm. in diameter, and of the density of the earth. The gravitation pull on it is 42,000 times the radiation pressure.

Now let us see the effect of size on the radiating body. Let us halve the diameter of the sun. He would then have one-eighth the mass and one-quarter the surface. Or, while his pull was reduced to one-eighth, his radiation push would only be reduced to one-quarter. The pull would now be

only 21,000 times the push. Halve the diameter again, and the pull would be only 10,500 times the push. Reduce the diameter to 1/42,000 of its original value, that is, to about 20 miles, and the pull would equal the push.

In other words, a sun as hot as ours and 20 miles in diameter would repel bodies less than 1 cm. in diameter, and could only hold in those which were larger.

But it is, of course, absurd to think of such a small sun as this having so high a temperature as 6000°. Let us then reduce the temperature to 1/20, say 300° absolute, or the temperature of the earth. Then the radiation would be reduced to the fourth power of 1/20, or 1/160,000, and the diameter would have to be reduced to 1/160,000 of 20 miles, or about 20 cm., say 8 inches, when again radiation would balance gravitation.

It is not very difficult to show that if we had two equal spheres each of the density and temperature of the earth they would neither attract nor repel each other—their radiation pressure would balance the gravitative pull—when their diameters were about 6·8 cm., when, in fact, they were about the size of cricket balls.

It must be remembered that this is only true for spheres out in space receiving no appreciable radiation from the surrounding region.

It would appear that we have arrived at a result of some importance in considering the aggregation of small meteorites. Imagine a thinly scattered stream of small meteorites at the distance of the earth from the sun. Then, even if they be as large as cricket balls, they may have no tendency to move together. If they are smaller they may even tend to move apart and scatter.

In conclusion, let me mention one more effect of this radiation pressure. You will remember that radiation presses back against any surface from which it issues. If, then, a sphere at rest in space is radiating equally on all sides it is pressed equally on all sides, and the net result is a balance between the pressures. But suppose that it is moving. It is following up the energy which it pours forth in front, crowding it into a smaller space than if it were at rest, making it more dense. Hence the pressure is slightly greater, and it can be shown that it is greater the greater the velocity and the higher the temperature. On the other hand, it is drawing away from the energy which it pours out behind, thinning it out, as it were, and the pressure at the back is slightly less than if the sphere were at rest.

The net result is a force opposing the motion, a force like viscous friction, always tending to reduce the speed.

Thus calculation shows that there is a retarding force on the earth as it moves along its orbit amounting in all to about 20 kgm., say 50 lb. Not very serious, for in billions of years it will only reduce the velocity by 1 in a million, and it will only have serious effects if the life of the earth is prolonged at its present temperature to hundreds of billions of years.

But here again size is everything. Reduce the diameter of the moving body, and the retarding effect increases in proportion to the reduction. If the earth were reduced to the size of a marble, the effect would be appreciable in a hundred thousand years. If it were reduced to a speck of dust a thousandth of a centimetre in diameter, the effect would be appreciable in a hundred years.

Note what the effect would be. Imagine a dust particle shot out from the earth and left behind to circulate on its own account round the sun. It would be heated by the sun and would be radiating out on all sides. As it journeyed forward there would be a resisting force tending to stop it. But instead of acting in this way the resistance would enable the sun to pull the particle inwards, and the fall inwards would actually increase the velocity. This increase in the velocity would increase the resistance, and at the same time the approach to the sun would raise its temperature, increase the radiation, and so increase the resistance still further. The particle would therefore move in a more and more rapid spiral orbit, and ultimately it would fall into the sun. Small marble-sized meteorites would fall in from the distance of the earth probably in a few million years. Small particles of dust would be swept in in a few thousand years.

Thus the sun is ever at work keeping the space round him free from dust. If the particles are very minute he drives them forth into outer space. If they are larger he draws them in. It is just possible that we have evidence of this drawing in in the zodiacal light, that vast dust-like ring which stretches from the sun outwards far beyond the orbit of the earth, and is at once the largest and the most mysterious member of the solar system.

PHYSICS AT THE BRITISH ASSOCIATION.

THE number of communications made to Section A this year was again so large as to necessitate duplicate sittings on several days, an arrangement which appears to bring home to members in a forcible manner the impossibility of being in two places at once. For some undiscovered reason the subcommittee which arranges the order of the papers is generally held responsible for this limitation, and gets a considerable amount of abuse. The disadvantage of the division was particularly evident at the discussion on the units used in meteorological measurements opened by Dr. W. N. Shaw. A subcommittee of the council of the association appointed to consider the question, recommends the use of the absolute zero of temperature with either the centigrade or Fahrenheit degree as the unit, but preferably the former, and the introduction of a new "degree of pressure" which is equal to 2000 C.G.S. units, and involves a graduation of the barometer in nearly 1/16th of an inch (0·06 in.), and the use of a vernier down to 1/160 inch. The meeting before which the matter was discussed was disposed to dwell mainly on the cost of effecting the changes proposed, and owing to the scant attendance of physicists, rather lost sight of the advantages of adopting what is practically equivalent to the C.G.S. system.

Attwood's machine as an aid to the teaching of dynamics was much discredited during the discussion of a paper by Mr. Eggar on an apparatus for verifying Newton's second law. Mr. Eggar finds that the movement of a truck down an inclined plane the angle of tilt of which can be altered, is much more convenient and effective than the fall of a weight.

The coefficient of expansion of hydrogen at various pressures down to low temperatures was the subject of a communication from Prof. Witkowski. He finds that the coefficient increases with decrease of temperature, and decreases with increase of pressure, a result which must have an important bearing on our standards of temperature.

Dr. Glazebrook's account of the recent work of the National Physical Laboratory made one hope that the efforts to cope with the demands made on it by our manufacturers for tests of materials and for scientific help of other kinds, will not be hampered by the insufficiency of the financial support the institution receives from the Government. In order to establish a scale of temperature, Dr. Harker has compared up to 1000° C. the constant volume nitrogen thermometer with a thermojunction previously standardised at the Reichsanstalt, and a platinum thermometer. Mr. Smith has constructed and compared a number of mercury standards of resistance, Dr. Stanton has been engaged in determining the amount and distribution of the pressure on structures due to wind, Dr. Carpenter has investigated the solidification of iron-carbon alloys, and a number of other important investigations have been carried out for manufacturers and for the Government.

Problems connected with radiation played a prominent part in the proceedings of the section. Prof. Poynting's interesting afternoon address, which appears in another part of the present issue, dealt with the applications of the laws of radiation to the solar system. Taking Stefan's law as a basis, the temperature of the sun works out as 6250° C., and that of a black body at the distance of the earth from the sun at 27° C., which agrees well with the average temperature of the earth. A description of an apparatus by means of which he had measured the tangential stress on a surface due to the oblique impact of light, was also given to the ordinary sectional meeting by Prof. Poynting. If E is the stream of momentum per sq. cm. per second due to the light incident at an angle θ, and μ is the fraction of the incident light reflected, the tangential pressure on the surface is $(1-\mu)/2.E \sin 2\theta$, and although in general it is smaller than the normal pressure,

the difficulties of its measurement are less owing to the reduction of the disturbing effects due to the surrounding gas.

Prof. Rubens gave an account of his recent work on the optical properties of metals for long waves obtained by his method of "Reststrahlen." The radiation had about 100 times the wave-length of the sodium line, and it was found that in this region the reflecting powers of metals are independent of the wave-length. In these circumstances Maxwell's theory gives for a good conductor $1-R=36\cdot5/\sqrt{\kappa.\lambda}$, where R is the amount reflected from the surface when unit radiation is incident on it, κ is the conductivity of the metal, and λ is the wave-length. The observations on pure metals and alloys agree with the theory, and show that the electrical conductivity of a metal may now be determined by a measurement of its reflecting power.

Prof. Wien, in discussing the question as to whether the ether moves with the earth or not, pointed out that according to the recent work of Lorentz, in which the electron is assumed to be ellipsoidal in form, attempts to settle the question based on interference or the rotation of the plane of polarisation would be without result. He thought himself the most promising method was a duplication of Foucault's revolving mirror method, the reflection taking place at the two ends from mirrors revolving with the same velocity. If the ether has a component movement along the line joining the mirrors the deflections observed at the two ends should differ.

Prof. Kayser directed attention to the defects of Rowland's scale of wave-lengths in view of the accuracy now attainable by interference methods of measuring wave-lengths. He considered that concave grating spectra were only suitable for interpolation purposes, and that the preparation of a standard scale should be taken in hand at once. Mr. Newall suggested that dark lines were more suitable than bright ones for this purpose.

Dr. Lummer, in describing his parallel plate spectroscope for the resolution of close spectral lines, pointed out the importance of high resolution if the effects of the mode of excitation or of an electrostatic field on the lines of a gas are to be investigated. Dr. Lummer showed his instrument in use in the Cavendish Laboratory, and was able to detect a difference between the lines of mercury, sodium, hydrogen, and helium when produced by Hertzian waves and when produced by the induction coil spark.

In connection with the preparation of the plates of the spectroscope, Lord Rayleigh mentioned that he had found the use of dilute hydrofluoric acid very effective in putting on the finishing touches to glass surfaces.

Prof. Wood described the interference method he had used to determine the dispersion of sodium vapour. The vapour was produced in an exhausted tube with plane ends surrounded by a wire by which the tube was electrically heated. Over a range extending to $\lambda^2/(\lambda^2-\lambda_m^2)=3900$ the results agree well with the formula $n^2=1+m\ \lambda^2/(\lambda^2-\lambda_m^2)$.

The discussion on "n-rays" was very one sided, as no one who spoke had succeeded in convincing himself that any effects he may have observed were not subjective.

Throughout the whole of the meeting communications dealing with radio-activity attracted a large amount of attention. Lord Kelvin described his models of radium atoms to give out α and β rays respectively. The former consisted of an "electrion" e placed at the point of contact of two spheres, through the volumes of which charges $-4e$ are uniformly distributed. When equilibrium is destroyed and the spheres move apart the electrion accompanies one sphere and we have the α particle. In the same way if two electrions e are in equilibrium at opposite extremities of a diameter of a sphere through the volume of which a charge $-\frac{1}{4}e$ is uniformly distributed, and equilibrium is destroyed, one of the electrions moves away from the sphere and gives the β ray.

Prof. Schuster described his apparatus in which radium is utilised in measuring the rate of production of ions in the atmosphere. Changes in the state of the atmosphere are found to take place much more rapidly than was anticipated, so that it is not advisable to use any method of measurement which involves the constancy of the state for more than five minutes.

Prof. Thomson gave an account of the work which has been done recently at the Cavendish Laboratory to determine whether ordinary matter possesses to a small extent the property of radio-activity so strongly shown by radium and polonium. His criterion for the possession of this property is that the substance shall be capable of producing electrical conductivity in the gas in a closed vessel in its neighbourhood. The difficulties of the investigation are due to the wide distribution of radium in soil, water, and air, and to the fact that the emanation from it settles on bodies left exposed to the air. A small quantity of radio-active material present in the body from either of these causes may be sufficient to mask the effect due to the substance itself.

From his observations Prof. Thomson concludes that each metal gives out a specific radiation which differs in its properties from the radiation sent out by other substances, and appears not to be a secondary radiation due to the impact on the substance of some form of penetrating radiation present in the atmosphere. The search for a radio-active gas produced by each metal has so far proved unsuccessful, but Prof. Thomson thinks there is some indirect evidence for the existence of such a gas.

Dr. Elster and Dr. Geitel pointed out that any results obtained by the use of the conducting property of a gas were open to the objection that the effects observed might still be due to traces of radio-active matter left in the apparatus, and not to the metals themselves.

Prof. Thomson's description of his work was necessarily much condensed, and physicists will look forward to the publication of a more complete account which will set aside this objection.

On the last morning of the meeting Prof. Fleming exhibited his apparatus for measuring the lengths of Hertzian waves such as are used in wireless telegraphy. A wire helix has attached to one end a metal plate which, with a similar plate attached to the apparatus in which the electrical oscillations originate, forms a condenser. The effective length of the helix is altered by a sliding conducting saddle, and the positions of the antinodes along the helix are determined by a Neon vacuum tube held perpendicular to the axis of the helix. From the dimensions of the helix the velocity of the waves along it can be calculated, and hence the frequency of the oscillation and its wave-length in air. Prof. Rubens stated that a similar method had been in use in Berlin for some time in connection with a portable apparatus for measuring the lengths of the waves used in the Slaby system of wireless telegraphy.

From the above notes of some of the matters brought forward it will be evident that the Cambridge meeting will hold its own as one of the most interesting of recent years.

C. H. LEES.

CHEMISTRY AT THE BRITISH ASSOCIATION.

THE proceedings of Section B (chemistry) were characterised not only by the general interest attaching to the numerous papers presented, but also by the unusually large attendances at the meetings, and chiefly by the presence of more than twenty distinguished Continental chemists, who made several important contributions to the business of the section.

The foreign visitors included Prof. Aschan (Helsingfors), Prof. Brühl (Heidelberg), Prof. Max Busch (Erlangen), Prof. Dieterici (Hanover), Dr. Etard (Paris), Prof. Franchimont (Leyden), Prof. M. Freund (Frankfurt), Prof. Gabriel (Berlin), M. le Comte de Gramont (Paris), Prof. Groth (Munich), Prof. Guye (Geneva), Prof. Haller (Paris), Prof. Kayser (Bonn), Prof. Knoevenagel (Heidelberg), Prof. Leduc (Paris), Prof. Richard Meyer (Brunswick), Dr. E. Noelting (Mülhausen), Prof. van Romburgh (Utrecht), Dr. Rupe (Bâle), Prof. I. Traube (Berlin), Prof. Walden (Riga), Prof. Wedekind (Tübingen), Prof. Wegscheider (Vienna), Prof. Wien (Würzburg), and Prof. Wolffenstein (Berlin).

The following papers were read:—On the bearing of the colour phenomena presented by radium compounds: W. Ackroyd. On the pentavalent nitrogen atom: Prof. O. Aschan. Saponarin, a glucoside coloured blue by iodine: Dr. G. Barger. The relation between the crystalline and the amorphous states as disclosed by the surface flow of solids: G. T. Beilby. The action of certain gases on glass in the neighbourhood of hot metals: G. T. Beilby. The change of conductivity in solutions during chemical re-

actions: P. V. Bevan. The union of hydrogen and oxygen in contact with a hot surface: Dr. W. A. Bone and R. V. Wheeler. On the formation of salts in solution, especially in tautomeric bodies: Prof. J. W. Brühl. On the active variety of chlorine: D. L. Chapman and C. H. Burgess. Hydroaromatic compounds: Prof. A. W. Crossley. On the energy of water and steam at high temperatures: Prof. C. Dieterici. A suggested explanation of the phenomena of opalescence observed in the neighbourhood of critical states: Prof. F. G. Donnan. On double acetylides: Major A. E. Edwards and Prof. W. R. E. Hodgkinson. Sur les manganates et les permanganates: Dr. A. Étard. Mesoxalic semialdehyde: H. J. H. Fenton. Note on the influence of radium radiations on atmospheric oxidation in presence of iron: H. J. H. Fenton. A reaction for ketoses: H. J. H. Fenton. A colour reaction for methylfurfural and its derivatives: H. J. H. Fenton and J. P. Millington. Ueber Isocystein (Isothioserin): Prof. S. Gabriel. Sur le spectre du souffre dans la photographie de l'étincelle des minéraux: M. le Comte de Gramont. Quelques observations sur le groupement des raies du spectre du silicium d'après l'effet de la self-induction, et sur leur présence dans les spectres stellaires: M. le Comte de Gramont. On crystal structure and its relations to chemical constitution: Prof. P. Groth. Methods of investigating alloys illustrated from the copper-tin series: C. T. Heycock and F. H. Neville. On some reactions between ammonium salts and metals: Prof. W. R. E. Hodgkinson and A. H. Coote. The stereochemistry of nitrogen: Dr. H. O. Jones. The constitution of nickel carbonyl: Dr. H. O. Jones. Exhibition of photographs of sections of an Australian siderite: Prof. A. Liversidge. On dynamic isomerism: Dr. T. M. Lowry. The oxidation of carbohydrates by hydrogen peroxide in presence of ferrous sulphate: R. S. Morrell and A. E. Bellars. Studies in the dynamic isomerism of α- and β-crotonic acids: R. S. Morrell and E. K. Hanson. The constitution of phthalein salts: Prof. Richard Meyer. The decomposition and synthesis of ammonia: Dr. E. P. Perman. Changes produced by the β rays: Sir William Ramsay. The action of organic bases on olefinic ketonic compounds: Dr. S. Ruhemann. (1) The vapour density of hydrazine hydrate; (2) the combining volumes of carbon monoxide and oxygen; (3) the action of heat on oxalates; (4) some alkyl derivatives of sulphur, selenium, and tellurion: Dr. A. Scott. A hexachlor-α-picoline and its derivatives: W. J. Sell. A new theory of the periodic law: G. J. Stokes. On the presence of arsenic in the body and its secretion by the kidneys: W. Thomson. On the velocity of osmosis and on solubility; a contribution to the theory of narcosis: Prof. Isidor Traube. Exhibition of effects produced by precipitating silver chromate in gelatin: Prof. Isidor Traube. The asymmetric nitrogen atom: Prof. E. Wedekind. On the products obtained by the action of tertiary bases on some acid chlorides: Prof. E. Wedekind. Pseudomorphosis in organic persulphates: Prof. R. Wolffenstein.

As in previous years, the practice of inviting two special reports on subjects of current interest and making these the basis of a discussion, met with considerable success, the communications of this order at the Cambridge meeting being made by Dr. H. O. Jones and Dr. T. M. Lowry; forming comprehensive summaries of our knowledge of the subjects discussed, which will be found very valuable by all who are engaged in teaching chemistry. The business of the section was brought to a conclusion on Tuesday afternoon by an address from Sir James Dewar on new low temperature phenomena and their scientific applications; this attracted a very large and appreciative audience, who followed the novel experiments with the greatest interest. The committees of the previous year were re-appointed, and two new committees were formed to deal with the subjects of dynamic isomerism and transformation of diazonium compounds and allied substances.

Although the neighbourhood of Cambridge does not offer many opportunities for studying industries of chemical interest, a very successful visit was made to the woad works near Wisbech, a description of which has appeared already in the columns of NATURE. Visitors were shown the processes of cropping, milling, and balling, and examined the drying racks on which the balls are placed until the second milling process, which takes place in November.

GEOLOGY AT THE BRITISH ASSOCIATION.

FOLLOWING the president's address, which has already appeared in these pages, Dr. Marr gave an address on the geology of Cambridgeshire. He described the main physical features of the county, and showed their relations to geological structure. Opportunities were afforded during the meeting, by afternoon excursions, for visiting most of the typical sections of Jurassic and Cretaceous rocks exposed near Cambridge, including the interesting occurrence of Upper Gault at Barnwell, in which Mr. Fearnsides recently discovered an unsuspected fauna. The Boulder-clays and gravels which cover a large portion of the surface of Cambridgeshire were dealt with by Dr. Marr in his address, and were further described by Messrs. Fearnsides and Rastall, who gave an account of the boulders collected by the members of the Sedgwick Club. Mr. F. W. Harmer, in a comprehensive paper on the Great Eastern Glacier, showed that its product, the Chalky Boulder-clay, extending over a great part of the eastern counties, has a palmate form, its lobes radiating from the great depression of the Lincolnshire and Cambridgeshire fens. The fens were the centre whence the Chalky Boulder-clay was distributed, and formed the quarry out of which was excavated the enormous mass of Jurassic material which forms the matrix of this deposit.

Much of the Boulder-clay about Leicester, in his opinion, was due to the ice stream of the Trent Valley having been piled up, upon the high lands to the east of Leicester, by the pressure of ice descending from the Pennine Chain. He found no evidence to show that any considerable amount of ice entered East Anglia through the Wash gap.

Mr. W. Whitaker showed that in the valley of the Stour deep channels filled with drift have been proved by borings, one of them having a depth of no less than 477 feet. How these channels extending below sea level have been excavated is a moot point, and in this connection Mr. Lamplugh pointed out that Dr. Gilbert has found in Alaska that the excavating power of ice debouching on the sea is carried on below sea level, and until the depth of water is sufficient to float the ice.

In a note on a small anticline in the Great Oolite series at Clapham, north of Bedford, Mr. H. B. Woodward directed attention to a small fold trending N.N.W. to S.S.E. Its direction is contrary to the minor undulations affecting the Oolitic strata of the district, and while there is no evidence to connect the disturbance with glacial action, there is equally no evidence against such a supposition.

Mr. John Spiller gave an account of the recent coast erosion in Suffolk, between Dunwich and Covehithe. At Easton losses of 39 feet and 55 feet have occurred at different points during the past two years.

A report on the fossiliferous drift deposits at Kirmington was read by Mr. J. W. Stather. A boring conducted by a committee appointed by the association proved solid chalk to exist at a depth of 93 feet, and above this were two boulder-clays separated by a bed of shingle and 18½ feet of laminated warp with estuarine shells. Thin peat and sand containing fresh-water shells were found at the base of the warp. The plants in the peat, according to Mr. Clement Reid, indicate estuarine conditions, and suggest a subarctic climate. Another boring at Great Limber showed a similar laminated warp, but without shells, and it does not rest on Glacial clays.

Mr. Edward Greenly, in describing the glaciation of Holyhead Mountain, showed that the northern and eastern slopes are strongly rubbed and rounded in a general N.E. to S.W. direction, and striæ occur on the summit 721 feet above sea level, parallel with the trend of the general glaciation of Anglesey. Mica schists, occurring *in situ* at a level of 200 to 300 feet, have been raised 500 feet above their source. He ascribes the phenomena to the action of land ice, and some ill-defined moraines composed of local débris he thinks may be due to small local glaciers.

Prof. P. F. Kendall presented a report of the committee on erratic blocks, and later exhibited a model of the Cleveland area showing glacier-lakes. He incidentally referred to a boulder of Red Crag of the Waltonian type found near Sherringham on the occasion of the association excursion to Cromer. The Rev. W. L. Carter, in describing the

glaciation of the Don and Dearne Valleys, sought to extend the system of glacier lakes and overflows of the Cleveland area further south, and in another paper dealing with river capture in the Don system he explained the present condition of the Don and its tributaries as resulting from a series of river captures due to the deep cutting of its valley by the Sheaf, and its predominant power in capturing consequent streams north and south.

Other papers dealing with Glacial and post-Glacial geology were read by the Rev. Dr. A. Irving, on stratified high-level gravels and their relation to the Boulder-clay; by Mr. A. W. Gibb, on the occurrence of pebbles of white chalk in Aberdeenshire Clay; the Rev. O. Fisher, on an elephant trench at Dewlish, Dorset; Mr. H. N. Davies, on the discovery of human remains under Stalagmite in Gough's Cave, Cheddar; and reports of committees were read on Irish caves, tidal action in the River Mersey, and underground waters of north-west Yorkshire.

On the day devoted to palæontology, Prof. Sollas gave an account of his new method of examining fossils by means of serial sections and their reconstruction by means of wax models. In this way he contrasted the structure of Ophiurids of recent and fossil types.

The finding of Holoptychius scales in the Cornstones of Salisbury Crag has led Drs. Horne and Peach to regard some of the beds occurring near Edinburgh, and hitherto thought to be of Carboniferous age, as belonging to the Old Red Sandstone period. Dr. Horne described the beds, and exhibited a revised map of the district. Dr. Traquair dealt with the fish remains found in the above deposits, and then read a paper on the fauna of the Upper Old Red Sandstone of the Moray Firth area, in which he summarised the results of many years' work.

Mr. G. W. Lamplugh directed attention to the fact that many of the phosphatic casts of fossils found in the Lower Cretaceous rocks at Upware, Potton, and Brickhill, and usually regarded as derivative, really are indigenous. At Speeton and in Lincolnshire these same fossils are found at their proper horizons, and indicate the life of the period. In another paper Mr. Lamplugh showed, by means of the marine fossils from the Ironstones of Shotover Hill, that the Ironstone originated through the alteration of a band of Portland Limestone.

Mr. E. A. Newell Arber, discussing the fossil plants of the Upper Culm Measures of Devon, concludes that the flora indicates an Upper Carboniferous age, and the coal-bearing beds of the Bideford district are the equivalents of the Middle Coal-measures elsewhere in Britain—a higher horizon than has previously been assigned to these beds.

In the same measures, too, he has found mineralised plant remains in the form of rolled fragments of stems, arranged without order in a fine grained sandstone. These are not contemporaneous with the sandstone.

The committee on the life zones in the British Carboniferous rocks reported investigations made in the Culm Measures of North Devon, the Pendleside series of the Derwent Valley, Derbyshire, the North Staffordshire Coalfield, and in South Wales.

The second report of the committee on the fauna and flora of the Trias included an elaborate description of rhyncosauroid and chelonoid footprints, beautifully illustrated by photographs by Mr. H. C. Beasley, and lists of Triassic fossils in the Jermyn Street and British Museums by Mr. E. T. Newton and Dr. A. Smith Woodward.

Prof. H. G. Seeley exhibited and described fossil footprints of reptiles from the Stormberg beds of the Karroo of Cape Colony.

In petrology and mineralogy eight papers were read. One, by Prof. H. Bäckström, was of great interest as showing that the great iron ore deposits of Lappland have been brought up by volcanic agency from great depths.

Mr. A. Harker exhibited a series of Tertiary Plutonic rocks (including gneisses) from the Isle of Rum. He described the characters and distribution of the earlier ultrabasic group. Into these eucrite has been intruded, and later an acid magma. The complex was then streaked out by movement, and well banded gneisses of the Lewisian type were formed.

Mr. E. Greenly suggested that the recent lava-pyramid formed on Mont Pelée might afford a clue to the origin of the lava domes of the Eifel.

Prof. H. A. Miers, dealing with the occurrence of gold in pyrites crystals, showed that in the Urals fresh crystals contained the gold uniformly disseminated, whereas on weathering into limonite the gold formed a nugget in the middle with crystalline facets. As other examples of concentration due to the attractive forces of crystallisation, he cited gypsum in clay, marcasite, pyrites, barytes, and phosphatic nodules.

Mr. Lamplugh, in the discussion which followed, remarked that the "dead earth is alive all the time," and gave instances where the formation of nodules has crushed the surrounding shales.

The basic patches occurring in the Mount Sorrel Granite, according to Mr. R. H. Rastall, are all inclusions of foreign material, and are not the result of concretionary action.

Papers were also read on the different modifications of zircon by Mr. L. J. Spencer, and on three new minerals and curious crystals of blende from the Binnenthal by Mr. R. H. Solly.

The granite from Gready in Cornwall was described by Prof. K. Busz.

The geology of the Oban Hills, Southern Nigeria, by Mr. J. Parkinson, and the report of the committee on geological photographs, complete the list of papers read in Section C, with the exception of a paper by Prof. Kendall on evidence in the Secondary rocks of persistent movement in the Charnian Range, and the discussion on the nature and origin of earth movements, an account of which is subjoined.

Discussion on the Nature and Origin of Earth Movements.

The president, in introducing the subject, which proved to be one of the most attractive features of the section, observed that movements of the earth's crust manifesting themselves in the fracturing, overthrusting, and folding of strata had been in operation from the earliest to the latest geological periods, and though intermittent so far as any one region was concerned, there was reason to believe that they had been more or less continuously in action throughout the world as a whole. Their operations, in fact, were essential to the existence of land surfaces, for in their absence all rocks projecting above the sea would be worn away, and the globe would be enveloped in one continuous ocean. Notwithstanding these facts, no theory as to the cause of the movements has commanded universal acceptance.

While some hold that the shrinking of the globe by cooling and the efforts of the crust to adapt itself to the shrinking interior are the prime causes, others maintain that the scale on which folding and overthrusting in the crust have taken place is out of all proportion to the shrinking that can be attributed to such a cause.

Earth movements may be divided into two principal classes, namely, movements of expansion, which are evidenced by normal faulting, and movements of compression, such as are indicated by buckling, overthrusting, and shearing of strata, by the superinduced structures of cleavage and schistosity, and by the extrusion of granitic rocks and metamorphism.

Dr. Horne presented the evidence he had accumulated from observations in the north-west Highlands, and traced the types of movement from the unaltered areas to the areas showing the greatest disturbance of all, namely, the Moine schists. In one region the Moine schists have been pushed ten miles to the west, and are seen lying on undisturbed Cambrian Limestone. Some of the movements undoubtedly occurred in pre-Torridonian times, others succeeded almost up to the Devonian period.

The veteran geologist, the Rev. Osmond Fisher, said he used to think that the corrugations of the earth's crust were due to compression through the shrinking of the interior. To judge of the sufficiency of this cause, the first thing to be done was to seek a measure of the compression, and then compare the result of the effects of cooling with the actual amount of compression. The most satisfactory measure appeared to be the thickness of the layer which the corrugations would form if levelled down. In 1863 Lord Kelvin formulated a law of secular cooling upon the hypothesis of a solid interior. Adopting a probable value for the contraction of rocks in cooling, Mr. Fisher calculated

the thickness of the layer which would be produced by the corrugations resulting, and found it far short of that which the existing inequalities would form if levelled down. The discovery of a level of no strain within the crust by Mr. Mellard Reade and Dr. Davison further reduced the possible amount of corrugation. Even a substratum of liquid magma holding water gas in solution would not account for it, and he therefore argued that the substratum was affected by convection currents, which, ascending beneath the oceans, flowed horizontally towards and beneath the continents.

Mr. J. J. H. Teall discussed the petrological aspect of the general question, and divided the effects of movements upon rocks into two classes, easily separable, namely, local and regional. The former were confined to the immediate areas of dislocation, while the latter extended over tens or hundreds of square miles.

Local movements were characterised by fault breccias and mylonites, these being close grained, compact rocks formed by the crushing down of original rocks as in a mill. In some cases there was no crushing, the dykes being converted into foliated schists. In respect of regional effects, we have slaty cleavage due to mechanical deformation of extensive tracts of country. Foliation might be due to the original form of crystallisation or to earth movements after consolidation.

Prof. T. McKenny Hughes thought that lateral pressure, not necessarily horizontal, had produced almost every feature, and that faults were due to compression occasioned by such pressure rather than by extension.

The folding skin of an apple due to shrinkage of the interior was not wholly comparable to earth folding, for, in the case of the earth, many complex circumstances had to be taken into account. Time was one important point, as well as such forces as molecular deformation, temperature changes, volume and force of crystallisation, and transference of material from one region to another.

Prof. W. J. Sollas said that the belts of folding could usually be correlated with the margins of preexisting oceans, and those belts of folding which were comparatively superficial must be accounted for by deep-seated causes. The inequality of the present earth was the best guide to former folding. Inequality at the meeting places of oceans and continents, together with sedimentary deposits on the ocean floor, altered the isothermal lines—flattening them out—and so produced stresses and thrusts, which resulted in pushing part of the material seawards. Thus there was a redistribution of pressure, and this produced fluid magmas, with earthquakes and volcanoes resulting. He thought that all this, however, would hardly suffice for the results produced. There must be another cause. The earth was more pear-shaped in the past than it now is by reason of its relation to the moon. Constant deformation towards its present shape produced contraction of the two hemispheres, and thus the American and Australian beltings or folds were, he thought, accounted for. Deformation of this character produced the same effects as contraction, and the two causes together, he considered, might be enough to account for the existing phenomena produced by earth movements.

Sir John Evans remarked that thirty years ago he had argued that if a globe with a fluid nucleus and a solid crust were postulated, deposition or other causes would result in the solid crust moving over the nucleus, and this disturbance would produce a change in the position of the pole. There was evidence of such a change in the fossil fauna and flora of the Arctic and Antarctic regions. This might be an additional aid beyond those due to cooling.

Prof. Blake thought that, in speaking of thrusts, Dr. Horne had only given the description, and not the cause. In the north of Scotland, where did the force come from? He suggested that if mountains expanded upwards by lateral or upward pressure, a sufficient cause for such thrusts would be found. He had never, he said, seen a true isoclinal fold, and he considered it mathematically impossible for one to exist; the nearest to it in nature was a pleisioclinal fold.

Prof. Rothpletz, of Munich, referred to overthrusts he had observed in Saxony twenty-five years ago. The Scotch overthrusts were older than those of the Alps. In the Alps the plane of the overthrust got steeper and steeper as it approached Vienna. When the folding was a shortening of the earth's crust, the overthrust was a shortening too, in another direction. The matter was more difficult of observation in Scotland, as the overthrusts ended in the sea.

Prof. Boyd Dawkins referred to a case in the Derwent Valley where folding had taken place over level beds, and thought they were not necessarily formed at the root below mountains.

Prof. J. Milne submitted that the seismologist required a world like that of the physicist, one as rigid as cast iron. Earthquake waves traverse chords of the earth at 11 or 12 km. a second, *i.e.* twice as rapid as through steel. This indicates a world very rigid and uniform in the interior. He thought that if it were liquid with convection currents, as urged by Mr. Fisher, the velocity of tremors would not be uniform.

Dr. Knott advised caution in accepting the abrupt change from solid to liquid as supposed by Prof. Sollas. The changes from solid to liquid would probably be through a viscous condition.

Prof. Kendall, in winding up the discussion, pointed out that the special feature of continental margins was deposition. Deposits, acting as imperfectly conducting blankets, would cause the isotherms and the critical zone to rise, and the weakest spot would give way. Given stiff rocks above the critical zone and plastic rocks below, puckering must take place. He considered that in thrust planes the rocks were not forced over horsts, but the horst was wedged underneath them. While areas of sedimentation were weak, other and thinner rocks were stationary under deforming stresses.

Following the discussion, Prof. Kendall read a paper on the evidence in the Secondary rocks of persistent movement in the Charnian Range, in which he gave specific examples of the movements which had been discussed by previous speakers. He referred to the speculations of Godwin Austen, who stated that all recent anticlines are built on older anticlines.

The Charnwood rocks showed evidence of folding in a N.E. to S.W. direction even before Cambrian times. These movements were continued in pre-Carboniferous, Carboniferous, and Permian times, and grounds existed for the belief that they were repeated at intervals during the Jurassic and Cretaceous periods. The Charnian axis, he believes, constitutes the boundary of two important coal fields which extend under the Secondary rocks far to the south.

J. LOMAS.

RECENT STUDIES OF DISEASE ORGANISMS.

AT the recent Cambridge meeting of the British Association, the results of several investigations of organisms associated with various diseases were described before the section of zoology, and are here summarised separately from the general report of the proceedings of the section, which will appear in another issue of NATURE.

Mr. A. E. Shipley, F.R.S., on behalf of Dr. Elliot Smith, gave a brief account of Looss's observations on *Ankylostoma duodenale* (miner's worm), and directed attention to the series of preparations sent by Prof. Looss from Cairo illustrative of his recent work. The male and female of this worm are found hanging in numbers to the intestinal walls of the man affected, and produce enormous numbers of eggs, which are discharged from the body. These give rise to small active worm-like larvæ which live in mud, and enter the body of man either along with food or through the skin, which they can penetrate without causing any visible lesion of the part. They then enter the lymph- and blood-vessels, are swept into the circulation, and eventually reach the lungs, where they pass from the blood-vessels into the air cavities. From the time the larvæ perforate the skin until they reach the lungs they remain the same size, but as soon as they reach the air vesicle they begin to grow rapidly. They pass into the bronchioles, up the bronchi and trachea, and, emerging through the glottis, pass down the œsophagus to the duodenum, where they become sexually mature. The bare-footed races of the tropics and subtropics, both in the Old World and America, are widely and generally infected with this worm, which produces severe anæmia, often ending in the death of the host.

Mr. G. P. Bidder pointed out the great economic importance of Looss's researches. He stated that experts now believed the majority of cases in the Cornish tin mines were due to infection of the bare shoulders, arms and hands, through coming into contact with some polluted surface in the mine. Against such infection, cleanliness in feeding, which has been recommended as the principal precaution, is of no avail. The question is a serious one, as the disease is grave, and there are half a million men working in our coal mines. Though as many as 80 per cent. of the men were affected in some Continental mines, the disease does not at present exist in British collieries; but in many of these there are those conditions of temperature and humidity which would be favourable to its propagation.

Prof. Simmers (Cairo) commented on the paper from an experience of thousands of cases. Nothing resembling the "miners' bunches" which have been described as occurring in Cornwall has been met with in Cairo. Looss's experiments on puppies point to a definite toxic effect on the tissues penetrated by the larvæ. A remarkable feature about the adult parasite is the absence of any wounds or bleeding on the intestinal wall to which it adheres. The muscular mouth of the worm appears to draw up the tissues into a sort of bell, and at the same time to secrete into the blood some substance which has the power of breaking up the constituents of the blood, so causing the peculiar anæmia.

Prof. G. N. Calkins gave to the section an account of his work on *Cytoryctes variolae*, Guarnieri, the organism of small-pox. After the inoculation of a rabbit's cornea with vaccine virus, Guarnieri (1892) found in the cells peculiar homogeneous structures of diverse form and size, and regarded them as Protozoa. Pathologists, however, do not accept this conclusion, as the "Guarnieri bodies" have no apparent structure, and cannot be cultivated on artificial media. Prof. Calkins considered these objections were dispelled by the experiments of Wasielewsky (1901), who vaccinated a rabbit with a small quantity of virus; from this a second rabbit was vaccinated, from the latter a third, and so on until forty-seven had been successfully inoculated. In all the rabbits the "Guarnieri bodies" were found, and Prof. Calkins believes they had undergone growth and multiplication—the attributes of a living organism. In 1902 Councilman discovered, in addition to the usual bodies in the cytoplasm, peculiar and definite bodies in the nuclei of skin-cells infected with small-pox. Prof. Calkins has worked over this material (from fifty-five cases), and has formulated a life-history. The first appearance of the organism in the human skin is a minute homogeneous spherule which enlarges and differentiates into two substances, one destined to give rise to the multiplication elements, the other forming an enveloping matrix. The organism increases in size until it is larger than the cell nucleus. The gemmules repeat the cycle again and again, thus giving rise to auto-infection of the vaccinia type. In later stages the gemmules enter the nucleus, where they develop into two kinds of structures, possibly male and female gametocytes. From the latter a sporoblast stage arises, the sporoblasts increase in size, and ultimately give rise to spores. Meantime, the nuclear membrane has been ruptured and the sporoblasts liberated. The spores are hollow spherules 0·5μ in diameter. Spores may be found scattered in the cytoplasm and in the nucleus, but it is only in the latter that they can develop further.

After Mr. J. J. Lister, F.R.S., had commented on the apparent absence of a definite nucleus, Dr. S. Monckton Copeman, F.R.S., mentioned that in a paper by Dr. Gustav Mann and himself (1898–9) practically all the features described by Prof. Calkins are shown, but that their interpretations are entirely different. They regarded the "Guarnieri bodies" as masses of nucleo-proteid material which have been extruded into the perinuclear space as the result of specific irritation, and it is noteworthy that these bodies are all found, in cases of inoculated variola or vaccinia, on the side of the nucleus *remote* from the point of inoculation, whereas the reverse might be expected if they were Protozoa. Similar appearances have been described by Pfeiffer and others in carcinoma, sarcoma, chicken-pox, and various vesicular skin diseases, all of which diseases cannot be due to the same specific agent. The specific zymotic disease which in all respects—period of inoculation, progress, affection of the skin and mucous membranes, production of immunity, &c.—most closely resembles small-pox, viz. enteric or typhoid fever, is now acknowledged to be a bacillary disease, and there would seem to be reason for believing small-pox to be due to an invasion of the system by a similar organism. Dr. Copeman considers that the small bacillus, which he demonstrated at the Liverpool meeting, which stains with great difficulty and cannot be grown on any of the ordinary laboratory media, represents the specific virus of small-pox and vaccinia.

Dr. J. A. Murray, of the Imperial Cancer Research Fund, read to the section a paper on the biological significance of certain aspects of the general pathology of cancer. He stated that both benign and malignant new growths increase their characteristic parenchyma entirely from their own resources, and there is no evidence of the transformation of the original tissue into malignant tissue, although the latter may be indistinguishable histologically from that among which it takes its origin. The cells increase by division; amitosis does occur, but mitotic division is much more common in fully developed tumours. Multipolar mitoses are common. The active growth and extension of the malignant tissue as manifested at the growing surfaces of a malignant new growth, are effected by cell divisions which, so far as they are mitotic, conform to the ordinary type met with in early development. The number of chromosomes entering the equatorial plate is constant in each species, and they undergo the usual longitudinal splitting. Passing from the growing margin towards the older parts of the growth, it is seen that some of the mitoses are characterised by the presence of bivalent chromosomes (heterotype), in number half that found in the younger parts. These heterotypes must be regarded as occurring late in the life-history of the cells in which they are present. The analogy of spermatogenesis suggests that the heterotype initiates a terminal phase in the life-history of the cancer cell as in the spermatocyte. While studying the changes which occur immediately after transplantation in a tumour of the mouse, nuclear changes were observed which presented a close similarity to a conjugation process. Subsequent observations (on more than 1000 tumours of all ages from three different primary sources) have tended to confirm this interpretation. Numerous secondary centres of growth are always found around the periphery of older tumours, and these secondary masses may in time outgrow that which preceded them. It is suggested that the cells which conjugate are those which have passed through a reducing division, but until the complete cycle is elucidated this must remain only a working hypothesis.

THE EVOLUTION OF THE HORSE.[1]

PROF. H. F. OSBORN referred to the three independent lines of research being carried on by Profs. Ewart, Ridgeway, and himself, and hoped that they would be able to bridge the interval which at present existed between the fossil, the historic, and the recent races of horses. He gave an account of the explorations, begun three years ago, of the American Museum, which were rendered possible by a liberal gift from the Hon. W. C. Whitney. The object of this research into the fossil history of the horse was to connect all the links between the Lower Eocene five-toed and the Lower Pleistocene one-toed horses, and to ascertain the relations of the latter to the horses, asses, and zebras of Eurasia and Africa. The first result obtained is the proof of the multiple nature of the evolution of the horse during the American Oligocene and Miocene periods. Instead of a single series, as formerly supposed, there are five—one leading to Neohipparion, the most specialised antelope-like horse which has ever been found; a second, of intermediate form, probably leading through Protohippus to Equus, as Leidy and Marsh supposed; a third leading to the Upper Miocene Hypohippus, a persistently primitive, probably forest- or swamp-living horse, with short-crowned teeth adapted to browsing rather than grazing, and with three spreading toes; this horse has recently also been found in China. A fourth and fifth line of Oligocene-Miocene horses became early extinct. This polyphyletic or multiple law is

[1] Abstracts of three addresses given in Section D of the British Association on August 23.

quite in harmony with the multiple origin of the historic and recent races of horses as recently established by Profs. Ridgeway and Ewart. The Pliocene horse of America still requires further exploration before it can be positively affirmed either that all the links to Equus are complete or that America is indubitably the source of this genus. The Lower Pleistocene of America exhibits a great variety of races, ranging in size from horses far more diminutive than the smallest Shetland to those exceeding the largest modern draught breeds—yet all these races became extinct, and did not survive into the human period as was the case in South America. The relations of these North American races to those of South America and of Asia and Africa is a subject requiring further investigation.

The address was illustrated by photographs of a large series of models, of osteological preparations showing the mechanism and breeds of the horse, and of the mounted fossil specimens recently discovered.

Prof. Ewart referred to the fact that in pre-Glacial times there were several distinct species of Equidæ in the New World, and that one of the objects of present inquiry is to connect the recent Equidæ with these or other extinct forms. Before it is possible to point out the connection between the true horses and the pre-Glacial or Pleistocene horses it is necessary to determine the number of species and varieties of the horse now extant. He described at some length Prjevalsky's horse, the Norse type of horse still found fairly pure in the north-west of Scotland, and the recently discovered Celtic pony. He referred to Prjevalsky's horse as the least specialised of living Equidæ, as evidenced by the character of its mane and tail and the presence of a complete set of callosities, and he discussed the question as to whether it is a mule or simply the offspring of Mongolian ponies run wild. The Norse type of horse differs from Prjevalsky's in its heavy mane and tail, finer head, and smaller ears. The Celtic pony is the most specialised of living Equidæ, as shown by the absence of such vestiges as fetlock-pads and chestnuts from the hind legs, and the presence of a peculiar tail-lock which adapts it for a sub-arctic habitat. Photographs were shown to illustrate these various features.

Prof. Ridgeway then stated some of the evidence which led him to conclude that a distinct species or variety of the horse had been specialised in North Africa. Darwin supposed that not only was the Arab horse the result of artificial breeding by the Arabs, but that the dark colour of the English racehorse was due to the Arab dislike of light coloured horses. History puts it beyond doubt that the Arabs had no horses at the beginning of the Christian era, and that they obtained their famous breed from North Africa, and, so far from their disliking light coloured horses, they have a predilection, on religious grounds, for white or grey horses, as had the Germans, Greeks, and Romans. Bay and other dark coloured horses were well known in northern Africa and western Asia many centuries before the Arabs owned horses. The horse appears for the first time on Egyptian monuments about 1500 B.C., and is almost always painted brown, and those ridden by Libyans and depicted on pottery (at Daphne, B.C. 660–570) are always painted dark. These horses were not imported into northern Africa from Asia; on the contrary, Solomon (tenth century B.C.) and his neighbours imported horses from Egypt which must have been of a superior race. These horses were obtained from the Libyan tribes (as none of the other peoples in that region possessed them), and from them also came those of southern Spain, the ancestors of the Andalusian and Pampas horses. The Libyan horses passed into Sicily and southern Italy, and in the games of Greece and in Roman times they were the fleetest known. The bay horse therefore not only belongs to Africa from the earliest times, but was then, as now, the swiftest. The Libyan horses show a greater tendency to stripes than do Asiatic horses, and the former often lack hock callosities, which are present and of large size in coarse Asiatic horses. The tail of the Libyan horse differs in structure, covering, and carriage from that of Asiatic horses; the hoofs are longer, and the neigh is different. Libyan horses were docile, and could be driven without bit, while the peoples who used Asio-European horses invented the bit. Prof. Ridgeway concludes that *Equus caballus libicus* is to be regarded as a distinct variety.

THE ACTION OF WOOD ON A PHOTOGRAPHIC PLATE IN THE DARK.[1]

IT has been shown in former papers that many substances are capable of acting on a photographic plate in the dark and producing a picture of themselves. Further investigation shows that this property belongs probably to all woods, some, however, being much more active than others.

To obtain a picture the wood has to be in contact or at a little distance above the photographic plate, and has to remain there for times varying from half an hour to eighteen hours, and to be at a temperature not higher than 55° C.

The wood of the conifers is very active, and gives pictures which are very definite. Fig. 1 is a picture of a section of a branch of a Scotch fir, and shows well the rings of spring and autumn growth. It is remarkable that the former are very active, producing in this picture the dark rings, and so with the other pictures, the part which is active in the original is dark in the picture. The rings seen in the wood are very sharp and strongly pronounced in the picture. If the action exerted on the plate be owing to the presence of hydrogen peroxide, as has been previously suggested, no doubt it is produced by the resinous bodies

FIG. 1.

present in the wood, but it is remarkable that there is no action from the dark autumn wood. Experiments described in the full paper show that resin exists in the dark rings, but apparently under such conditions that it cannot escape. Other members of the pine group have been experimented with and have been found to behave in the same way as the Scotch fir.

With the spruces the action on the plate is not so definite and well marked; the white wood is always active, but in some cases the dark rings are also active, and the pictures are not so sharp as with the firs. Larch wood gives a very interesting result, for the picture is the reverse of that of the Scotch fir, that is, the dark rings in the wood are the active rings and the light rings are inactive.

With regard to woods other than conifers, oak and beech are both active and give very good pictures, so also does acacia (Robinia), Spanish chestnut, and sycamore; on the other hand, ash, elm, horse chestnut, plane are comparatively but slightly active. In the full paper lists of woods are arranged according to their activity.

Many foreign woods are very active, but as the annual rings are often not well developed, the pictures they give are of a somewhat different character. The African black wood, rose wood, cocobola, and many others are very active. Several of the foreign woods have a ring of white wood which is quite inactive.

[1] By Dr. William J. Russell, F.R.S. Read before the Royal Society, June 16.

Knots in a wood generally, but not always, give a good picture. Some of the resin in immediate contact with the knot is in some cases but little active. The marked difference in properties of resins from different sources is described, and it is shown how difficult it is to remove it so that the wood shall be no longer active. Boards that have been exposed to the air for a long time, an oak box a hundred or more years old, rotten wood from the stump of a tree, and even bog wood have all been found to be still active.

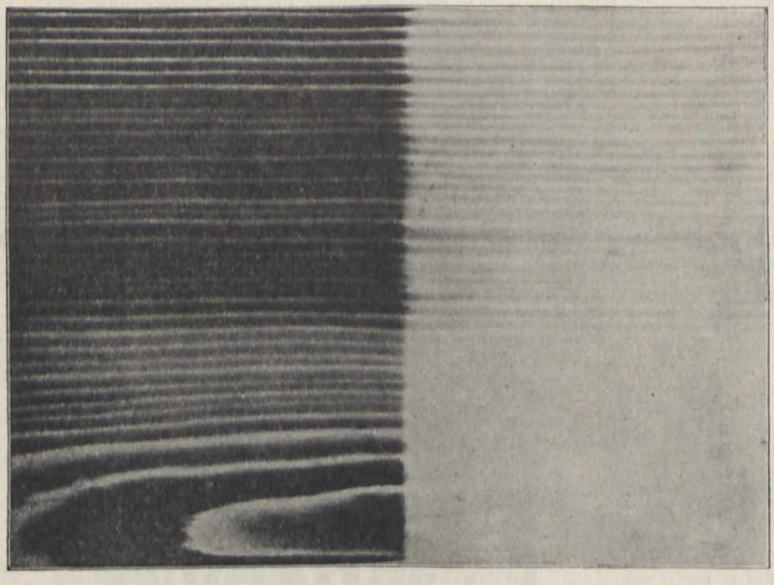


FIG. 2.

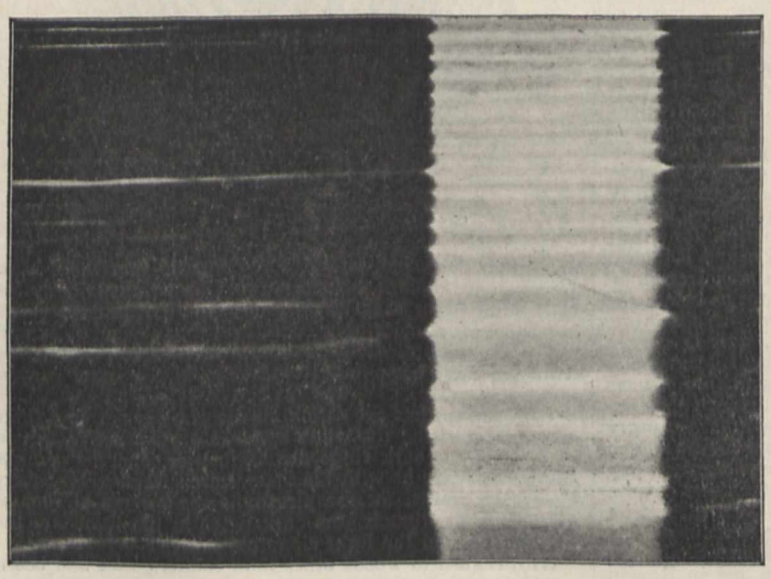


FIG. 3.

In addition to woods many different resins and allied bodies can, when used alone, be proved to be very active, some naturally much more so than others. Ordinary resins, Burgundy pitch, gum mastic, are very active, asphaltum, dragon's blood much less so, but true gums such as gum senegal and gum arabic are entirely without action on a photographic plate.

In certain cases the picture obtained on the plate does not resemble the markings which are visible on the wood. With some woods this more commonly occurs than with others. That this picture is persistent in the wood is shown by fresh sections giving the same result. The true bark of a wood is apparently quite without action on a photographic plate, so is the internal pith of a plant.

There is another and a very interesting action which occurs with wood; it is the great increase of activity which it exerts on a photographic plate after it has been exposed to a strong light. For instance, if a piece of deal be half covered by black paper or tin foil and be exposed for five to ten minutes to bright sunlight, and then put up in the usual way with a photographic plate, it will give a dark picture where the light has fallen on the wood and only a very faint picture of the part which has been covered. This is shown in Fig. 2. Even comparatively inactive woods such as elm and ivy after a short exposure to bright light give good and dark pictures. The action is not an indiscriminate darkening over the whole wood section, but an intensifying of the parts already active. This increase of activity by the action of light appears to occur with all woods. Artificial light, such as that from the electric arc, or from burning magnesium ribbon, act in the same way, so does even a faint light. A piece of wood put at a window for some hours will give a darker picture than a similar piece left in the middle of the room. This increase of power of a wood to produce a picture does not rapidly pass away. After twenty-four hours the action is visibly less, and decreases more rapidly at first than after some days, but it will be a fortnight or may be a month before the wood resumes its former condition. This action, like the former one, is entirely stopped by interposing the thinnest piece of glass or mica between the photographic plate and the active body. An inactive card painted with an alcoholic solution of resin acts in the same way, and turpentine which has been exposed to a bright light acts more strongly on a photographic plate than it does when it has not been so exposed. Again, old printing which is now nearly inactive becomes much more active after exposure to sunlight. Bodies other than those which may contain resin or allied substances are not affected in this way by light, for instance, flour, sugar, porcelain; metals are not rendered active by sunlight.

The next point was to ascertain which of the constituents of light was most active in producing these effects, and the first experiments were made by simply placing strips of different coloured glass on wood sections, exposing them to sunlight and afterwards putting them up with the photographic plate in the usual way. Pictures of the results are given in the paper. Red glass entirely prevented any increase in the activity of the wood, in fact, it acted in the same way as a band of black paper or tin foil would act, and a green glass acted much in the same way, but under a blue glass the activity of the wood was increased to much the same extent as under colourless glass or under no glass. Fig. 3 shows what happens when a red glass and a white glass are placed upon it and is exposed to sunlight. On the right of the figure there was no glass.

Further experiments were made by placing similar pieces of deal in light which had passed through different coloured solutions. Three double-cased bell jars were taken; one

was charged with a solution of potassium bichromate, another with copper ammonium sulphate solution, and the third with pure water, and all were exposed to sunlight for four hours. The deal in the red light gave only a faint picture, that in the blue light a dark picture, and that with the pure water was only a slightly darker picture. Resin, guaiacum, copal varnish, white oil paint and resin sized paper all acted in the same way and gave similar results.

The light from an arc lamp when passed through a red glass and allowed to fall on a wood section for one and a half hours produced no effect, but when the same light was passed through a blue glass and fell on a similar wood section for only one hour it produced a dark picture. With liquids this same increase of activity by the action of blue light is produced. Turpentine, which has been exposed to blue light, is more active than when in its ordinary condition.

THE DENSITY OF NITROUS OXIDE.[1]

IN the *Proceedings*, vol. lxxii. p. 204, 1897,[2] I have given particulars of weighings of nitrous oxide purified by two distinct methods. In the first procedure, solution in water was employed as a means of separating less soluble impurities, and the result was 3·6356 grams. In the second method a process of fractional distillation was employed. Gas drawn from the liquid so prepared gave 3·6362. These numbers may be taken to represent the corrected weight of the gas which fills the globe at 0° C. and at the pressure of the gauge (at 15°), and they correspond to 2·6276 for oxygen.

Inasmuch as nitrous oxide is heavier than the impurities likely to be contained in it, the second number was the more probable. But as I thought that the first method should also have given a good result, I contented myself with the mean of the two methods, viz. 3·6359, from which I calculated that, referred to air (free from H_2O and CO_2) as unity, the density of nitrous oxide was 1·52951.

The corresponding density found by M. Leduc is 1·5301, appreciably higher than mine; and M. Leduc argues that the gas weighed by me must still have contained one or two thousandths of nitrogen.[3] According to him the weight of the gas contained in my globe should be 3·6374, or 1·5 milligrams above the mean of the two methods.

Wishing, if possible, to resolve the question thus raised, I have lately resumed these researches, purifying the nitrous oxide with the aid of liquid air kindly placed at my disposal by Sir J. Dewar, but I have not succeeded in raising the weight of my gas by more than a fraction of the discrepancy (1·5 milligrams). I have experimented with gas carefully prepared in the laboratory from nitrate of ammonia, but as most of the work related to material specially supplied in an iron bottle I will limit myself to it.

There are two ways in which the gas may be drawn from the supply. When the valve is upwards, the supply comes from the vapourous portion within the bottle, but when the valve is downwards, from the liquid portion. The latter is the more free from relatively volatile impurities, and accordingly gives the higher weight, and the difference between the two affords an indication of the amount of impurity present. After treatment with caustic alkali and sulphuric acid, the gas is conducted through a tap, which is closed when it is desired to make a vacuum over the frozen mass, and thence over phosphoric anhydride to the globe. For the details of apparatus, &c., reference must be made to former papers.

The first experiment on July 13 was upon gas from the top of the bottle as supplied, and without treatment by liquid air, with the view of finding out the worst. The weight was 3·6015, about 35 milligrams too light. The stock of material was then purified, much as in 1896. For this purpose the bottle was cooled in ice and salt[4] and allowed during about one hour to blow off half its contents, being subjected to violent shaking at frequent intervals. Subsequently three weighings were carried out with gas drawn from the bottom, but without treatment by liquid air. The results stand:—July 18, 3·6368; July 20, 3·6360; July 25, 3·6362; mean, 3·63633.

Next followed experiments in which gas, still drawn from the bottom of the bottle, was further purified by condensation with liquid air. On one occasion (August 7) the condensed gas was allowed to *liquefy*, for which purpose the pressure must rise to not far short of atmospheric, and to blow off part of its contents:—August 1, 3·6363; August 3, 3·6367; August 7, 3·6366; mean, 3·63653.

The treatment with liquid air raised the weight by only 0·2 milligram, but the improvement is probably real. That the stock in the bottle still contained appreciable impurity is indicated by a weighing on August 13, in which without liquid air the gas was drawn from the *top* of the bottle. There appeared, August 13, 3·6354, about 1 milligram short of the proper weight.

It will be seen that the result without liquid air is almost identical with that found by the same method in 1896, and that the further purification by means of liquid air raises the weight only to 3·6365. I find it difficult to believe that so purified the gas still contains appreciable quantities of nitrogen.

The corresponding weight of air being 2·3772,[1] we find that, referred to air as unity, the density of nitrous oxide is $3·6365/2·3772 = 1·5297$. Again, if oxygen be taken as 16, the density of nitrous oxide will be $3·6365 \times 16/2·6276 = 22·143$.

The excess above 22 is doubtless principally due to the departure of nitrous oxide from Boyle's law between atmospheric pressure and a condition of great rarefaction. I hope shortly to be in a position to apply the connection which will allow us to infer what is the ratio of molecular weights according to Avogadro's rule.

1 By Lord Rayleigh, O.M., F.R.S. Abridged from a paper received at the Royal Society on September 1.

2 Or "Scientific Papers," vol. iv. p. 350.

3 "Recherches sur les Gaz" (Paris, 1898.)

4 The lower the temperature below the critical point, the more effective is this procedure likely to be.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. ERNEST SHEARER, Kirkwall, has been appointed lecturer on agriculture at the Pusa Imperial College, Bengal. This model agricultural college for all India, with a farm of 1300 acres attached, is one of the admirable developments resulting from the appointment two or three years ago of Mr. James Mollison as Inspector-General of Agriculture in India. Mr. Alexander Sangster, Montrose, has been appointed junior assistant with the Aboukir Land Reclamation Co., near Alexandria, Egypt, and Mr. John C. Leslie assistant conservator of forests in southern Nigeria.

THE approach of the new sessions at polytechnics and similar institutes is heralded by the appearance of calendars and prospectuses, several of which have been received within the past few days. At the Birkbeck College, Chancery Lane, the session will commence on Monday, October 3, when an inaugural address will be delivered by Dr. J. E. Mackenzie on "The Influence of Pure Science on Progress." The class-rooms and laboratories of the college will afterwards be open to inspection, and demonstrations will be given. A course in science with practical work has been organised to give complete preparation in metallurgy and mining for those qualifying for the mining profession. It is satisfactory to know that within the last few years valuable reference libraries have been provided for the separate departments of science; these have been aided by grants from the County Council. His Majesty's Treasury recently presented to the college forty-nine volumes of the scientific results of the *Challenger* Expedition.

THREE prospectuses have been received from the South-western Polytechnic, referring respectively to the day college for men and women, day school for boys and girls, and evening classes. The principal of the polytechnic is Mr. S. Skinner. The courses at the day college are arranged to occupy three years. On entering the student has to state whether he wishes to be trained as a mechanical, civil, or electrical engineer, or as a consulting or industrial chemist. In any of these cases he will find mapped out for him a complete course of study, involving laboratory instruction, tutorial work, attendance at lectures, exercises in mathematics, geometrical, mechanical and architectural drawing, and instruction in the workshops.

1 Roy. Soc. *Proc.*, vol. liii. p. 134, 1893; "Scientific Papers," vol. p. 47.

In the "Announcements" of the Northampton Institute, London, E.C., a table is given showing the courses which should be taken by various classes of technical students. This, as well as the sound advice given in many parts of the prospectus as to aims and methods of study, should be of great assistance in guiding the energies of students in right directions. Among the new developments of the institute are day courses in technical optics. These are believed to be the first complete day courses in technical optics attempted in this or any other country. In mechanical and electrical engineering complete day courses extending over four years are arranged. In mechanical engineering full evening courses for automobiles, their design, construction, and working, are offered. The courses in structural engineering have been re-modelled. The evening courses in electrical engineering have also been re-modelled, the complete course now covering five years.

The Board of Education has issued the following list of candidates successful in this year's competition for the Whitworth scholarships and exhibitions:—Scholarships, 125*l.* a year each (tenable for three years): Walter A. Scoble, London; Herbert G. Tisdall, Bedford; James Cunningham, Glasgow; Archibald D. Alexander, Portsmouth. Exhibitions, 50*l.* (tenable for one year): Sidney R. Dight, Plymouth; Edwin S. Crump, Wolverhampton; Harold H. Perring, Devonport; Sidney H. E. May, Portsmouth; William B. Wood, Sheerness; Alexander R. Horne, Edinburgh; Leslie G. Milner, London; John Wharton, Leeds; Thomas A. Colville, Chatham; Edward L. Macklin, Portsmouth; William D. McLaren, Glasgow; Arthur A. Rowse, Southsea; Arthur Rose, Portsmouth; Andrew Robertson, Fleetwood, Lancs.; Ernest J. Buckton, London; Roderick Ferguson, Sunderland; William Browning, Halifax; William Dawson, Glasgow; Herbert G. Taylor, Oldham; Sydney Moor, Devonport; Harold H. Broughton, Brighton; Robert C. P. Bricknell, Devonport; William E. Dommett, Southsea; John S. Mackay, Liverpool; Harry D. Marlow, Plumstead, Kent; Herbert E. Sothcott, Portsmouth; Sidney G. Winn, London; Samuel W. Orford, Sheerness; Thomas Fell, Bootle; Chauncy H. Sumner, London.

At the annual meeting of the Institution of Mining Engineers, held at Birmingham on September 14, Prof. R. A. S. Redmayne described the courses of instruction and study of the mining department of the University of Birmingham. The full three years' curriculum has been constructed on the principle of giving a thorough grounding in pure science during the first two years (with instruction in the theory and practice of mining), and devoting the third and last year entirely to the application of the scientific knowledge so acquired to engineering—mining, mechanical, civil, electrical, and metallurgical—all specialising and research work being relegated to a post-graduate or fourth year. The first year's work is devoted to such subjects as prospecting and boring, sinking, underground development and systems of working, surface and underground transport of minerals, winding, drainage, ventilation, sorting and screening of minerals, and surveying and planning. During the second year the details of colliery and mine management and mining jurisprudence are considered, in addition to which there is an advanced course in surveying and planning. To the third year is consigned the study of the foreign coal and metal mining conditions, and the dressing and preparation of fuels and ores for the market. There is a summer school of practical mining in every long vacation, the object being to devote several weeks in each year entirely to the detailed study of the plant and methods of working of a particular class of important mines, so that students may see for themselves in actual practice much that they have had described to them in the lecture theatre and class-rooms. An experimental coal-mine has been constructed a few feet below the surface, with which it is connected by a downcast and upcast shaft. The workings, the area of which somewhat exceeds three-quarters of an acre, will be ventilated by a single-inlet Capell fan, driven at 500 revolutions per minute by an electric motor of 20 horse-power, coupled direct; and they will be drained by a small electric pump placed at the bottom of the downcast shaft. The chief use to which this piece of apparatus will be put will be to enable practical instruction to be given in underground surveying and levelling, and connecting surface and underground surveys; and for demonstrating and investigating the peculiarities of mine-ventilation, such as the splitting of air currents and directing their course, the resistance to air currents, the loss of pressure due to friction, and the characteristics of mechanically produced ventilation.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 12.—M. Mascart in the chair.—On the comparative morphography of the cartilaginous cell: Joannes **Chatin**. The author disputes the generally accepted view that the normal shape of the cartilage cell is ovoid or spheroidal in the higher vertebrates, and shows that in cartilage from the badger there are undoubted examples of the stelliform type of cell.—The influence of grafting on the composition of the grape: G. **Curtel**. Clear evidence of differences in physical and chemical composition between grafted and non-grafted grapes has been obtained, and the facts observed explain the more rapid ageing of wines from grafted vines, and also their greater sensitiveness to pathogenic ferments.—Simple traumatic dislocation of the atlas on the axis on a skeleton found in a megalith of Vendée: Marcel **Baudouin**.—Observations on the preceding note: M. **Lannelongue**. The author regards the effects noted as probably due to *post mortem* changes.

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