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"*To the solid ground*
Of Nature trusts the mind which builds for aye."—WORDSWORTH.

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INDEX.

NAME INDEX.

TITLE INDEX.

ASTRONOMICAL NOTES.

CORRESPONDENCE.

REVIEWS AND OUR BOOKSHELF.

Agriculture, Forestry, and Horticulture:

Anthropology and Archæology:

Biology:

Chemistry :

Engineering:

Geography and Travel:

Medical Science:

Metallurgy:

Meteorology:

Miscellaneous:

Philosophy and Psychology:

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CONTENTS.

Editorial and Publishing Offices:
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Scientific Worthies.

XLIV.—ALBERT ABRAHAM MICHELSON.

THE co-operation of members of the English-speaking race is heartily welcome in many departments of human activity, some of them presumably more important even than the pursuit of science. But to us who are engaged in that study, the brilliant results obtained of late years in the United States, and the friendly co-operation existing between that country and the different parts of the British Empire, are a suitable subject of felicitation; and I am privileged to write an article in appreciation of the work of one of the most distinguished physicists in the world, the circumstances of whose normal life I understand to be as follows:

Albert Abraham Michelson was born in Strelno, Poland, on December 19, 1852. In 1854 his parents migrated to the United States. After emerging from High School in San Francisco, young Michelson was appointed to the Naval Academy, from which he graduated in 1873, and two years later became instructor in physics and chemistry under Admiral Sampson, continuing this work until 1879. After a year in the Nautical Almanac Office at Washington, Michelson, now an ensign, went abroad for further study at the Universities of Berlin and Heidelberg, and at the Collège de France and the École Polytechnique in Paris. Upon his return to the United States in 1883 he became professor of physics in the Case School of Applied Science, Cleveland, Ohio; whence, after six years, he was called to Clark University, where he remained as professor until 1892, when the University of Chicago opened its doors. Prof. Michelson went to this new institution as professor of physics and head of the department, a position which he still holds. In June 1925 he was honoured by being appointed to the first of the Distinguished Service Professorships made possible by the new development programme of the University.

It was while he was at Cleveland that Prof. Michelson collaborated with Prof. Morley in their joint experiment; and it may have been for the purpose of that experiment that he invented his particular form of interferometer, with the to-and-fro beams at right angles. Later, he applied it in Paris to the determination of the metre, with an estimated accuracy of about one part in two million.

During the World War, Prof. Michelson re-entered the Naval Service with the rank of Lieutenant-Commander, giving his entire time to seeking new devices for naval use, especially a range-finder, which became part of the U.S. Navy Equipment.

So recently as 1924 he undertook a very accurate determination of the velocity of light, using Mount Wilson and San Antonio, 22 miles apart, as the stations. It is believed that he intends to continue this with a base-line 90 miles long, so as to obtain this great fundamental constant with extreme accuracy.

A Nobel Prize was awarded to Prof. Michelson in 1907, the first American to get one for science; and the Copley Medal, the most distinguished honour of the Royal Society of London, was awarded him in the same year.

The gold medal of the Royal Astronomical Society was presented to Prof. Michelson on February 9, 1923; and the compact exposition of the reasons for that award, by the president, Prof. Eddington, on that occasion will be found in NATURE, vol. 111, p. 240.

As an expounder of scientific progress it is interesting to read Michelson's address given as retiring president of the American Association for the Advancement of Science, which fortunately has been reproduced in NATURE of January 11, 1912 (vol. 88, p. 362). It covers a lot of ground and the work of many people; and one characteristic of it is the slight emphasis on his own name in connexion with his own work.

Let us see if we can obtain some idea, not indeed of the whole scope of his work, but of some of the salient and outstanding features of it.

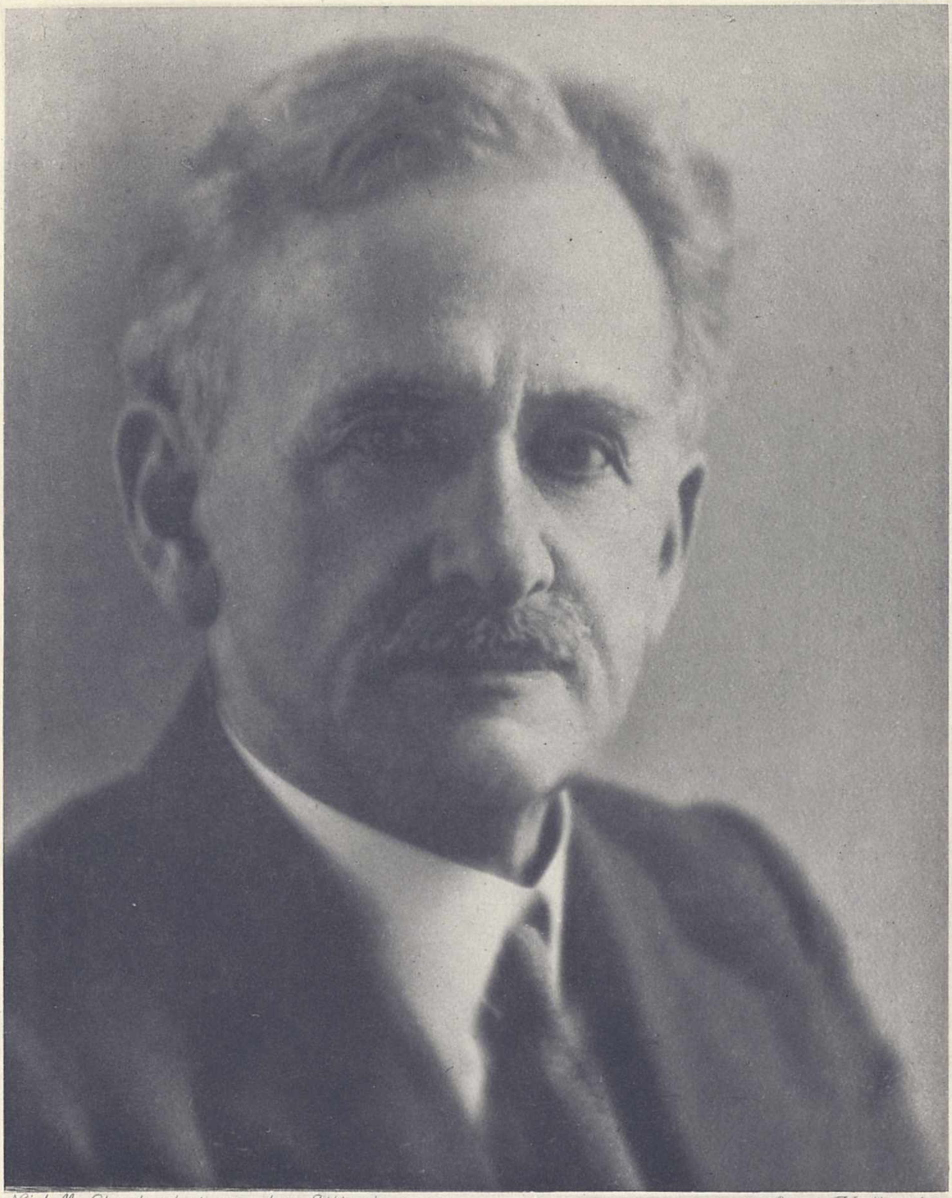
Michelson has touched on many departments of physics, but in optics, the highest optics, he excels. In this subject he can be regarded as the most fertile and brilliant disciple of the late Lord Rayleigh, for his inventions are based on a thorough assimilation of the principles of diffraction, interference, and resolving power; and his great practical achievements are the outcome of this knowledge. In this appreciation a reminder of some of the salient features of that work must be appropriate. But his papers cover far more than general principles; they enter into minute details, as is always necessary when theory has to be translated into experiment and instrumental construction. He has been happy in having at his command the possibilities of equipment provided by enlightened citizens of the United States of America; he has been aided by the singular skill of some instrument-makers both in the States and in Great Britain; but without a thorough grasp of theory his ingenious designs would have been impossible.

Michelson seems to have a special instinct for all phenomena connected with the interference of light, with a taste for exact measurement surpassed by none in this particular region. The interferometer with which he began became in his hands much more than an interferometer. He applied it to the determination of the standard metre in terms of the wave-length of light, with exact results which will enable remote posterity millions of years hence to reconstruct, if they want to, the standard measures in vogue at this day. He applied it also to analyse the complex structure of spectrum lines, and with remarkable completeness to determine the shape and size of invisible objects, such as to ordinary vision, however much aided by telescopic power, will probably remain mere points of light. NATURE is read by many other than physicists, and a rough general idea of how these things were accomplished may be welcomed.

The kind of interferometer dependent on the use of a semi-transparent plate was begun so long ago as 1859 by Fizeau, who thus split a beam of light into two halves, and with the aid of auxiliary silvered mirrors sent the beams round a circuit along identical paths in opposite directions, so as to become reunited at their point of separation. Thus, by alternate concurrences and oppositions of phase, the illumination was redistributed into bands of remarkable brilliance, which bands would shift in position if any cause accelerated one of the half beams and retarded the other.

Michelson modified this arrangement by altering the angle of the auxiliary mirrors, and setting them perpendicular to the light, so as not to send the two beams round a contour, but to reflect each back upon itself. Each half-beam then makes a to-and-fro journey along its own path, the interference fringes being produced, as before, when the beams reunite at their point of initial separation at the end of their independent journeys. The accidents which can happen to such separated beams are of a different character from those operative in the Fizeau arrangement, and it becomes a different instrument.

If we begin with the two paths equal, noting the position of the fringes by a micrometric device, and then gradually lengthen one of the paths by making its perpendicular mirror retreat, the bands will shift so as to interchange bright for dark when the mirror has retreated a quarter-wave length—which, of course, is an exceedingly small amount. If, by a screw motion, we make the mirror gradually move backwards, an eye at the micrometer will see the bands sailing or floating past, in such a way that their passage can be counted; and we can thereby determine how many wave-lengths the mirror has retreated. We might thus cautiously move it back a centimetre, or even a decimetre, and might then, by ingenious devices and different standard



Niel M. Clark, photographer, Illinois   Emery Walker ph. sc.

A. A. Michelson

gauges of length, gradually extend the range virtually to as much as a metre: thus counting with extreme precision, and to a small fraction, the number of waves in that length,—using, of course, very homogeneous light, such as is given by a line in the spectrum of cadmium or mercury, or other monatomic substance emitting a simple kind of light.

Now suppose the source of light is not simple: suppose instead of being a single line, it is a double one. Then what will be the effect? The wave-length of the two lines is slightly different. With some adjustments the interference bands may agree in position, so that they are clear and plainly visible: with other adjustments the bright parts of one set may overlap or be superposed upon the dark parts of the other; thus restoring a uniform illumination, and making the bands disappear. A further adjustment in the same direction will cause them to reappear again, and so on periodically. By studying these variations of visibility, and plotting a curve to represent them, after the manner of Rayleigh (see his "Investigations in Optics," *Phil. Mag.*, 1879 and 1880, or Paper Number 62, in vol. i. of his "Collected Scientific Papers"), the nature of the source can be specified with precision, and the relative intensity of the components of the double or multiple source ascertained.

Perhaps the easiest way of getting a general idea of the process is to employ a very simple interference instrument, such as two parallel slits in a card, mounted in a tube like a taper-holder, to which the eye is applied, and then look at a fine line of light like a luminous hair. Interference bands will be seen, caused by the meeting and overlapping of the beams which have come through the two slits. (Lord Rayleigh describes such an easily-made and popular instrument in vol. iv. of the "Collected Papers," p. 76.) Now imagine the source of light shifted parallel to itself, through a distance which when multiplied by a reducing fraction (the ratio of the distance between the slits to their distance from the source) will equal half a wave-length of light. The bands will now look the same as before, but the bright bands will be in the dark bands' places; thus indicating the amount which corresponds to a half wave-length shift. Next, imagine a precisely similar source placed in the original position, and look at the two together. Each will give its own set of bands, but no bands will be visible, because the bright parts of the one will blot out the dark parts of the other. Separate the two sources a little more, or bring them a little nearer together, and in either case the bands will reappear.

We may next proceed to consider what happens when, instead of the two simple sources of light, a square or oblong patch of light is looked at, filling up the space between the two positions. The thing is now becoming a little more complicated, and a numerical factor will have to be introduced depending on the shape of the source of light. It need not be an oblong; it might be a triangular patch, or a circular disc, or any other simple shape. Michelson made a serious study of what would happen for all manner of luminous apertures, and found that a numerical factor could be introduced appropriate to each simple shape, and drew the visibility curve to be expected under the various conditions. This paper will be found in the *Phil. Mag.* for April 1891; and in September 1892 his later paper applied the curves to determine the peculiarities of spectrum lines employed as the source of light.

Before that, however, Michelson had realised that on Rayleigh's principles the resolving power of a telescope could be indefinitely increased by using it to form, not an ordinary image of an object, but the diffraction or interference pattern of such an object.

An early paper by Lord Rayleigh on "The Resolving Power of Spectroscopes," in which the main theory is given, is in the *Phil. Mag.* for March 1874. (See also vol. i. of "Collected Papers," pp. 216, 420, and 424.)

Early in the century that remarkable genius, Thomas Young, had devised what he called an "eriometer" for measuring the size even of very minute granules by their diffraction pattern,—for example, the rings of the halo formed by such a substance as lycopodium. Rayleigh suggested an extension of this method in his "Encyclopædia Britannica" article, "Wave Theory," where he gave the theory of different apertures, and refers to previous workers in France and elsewhere. (Paper Number 148 in vol. iii. of "Collected Papers.")

Michelson pursued the subject into great detail; and in a magnificent paper in the *Phil. Mag.* of July 1890 he suggested the application of interference methods to astronomy. He knew well that the resolving power of a telescope depended on the diameter of its aperture, and that the formation of an image was essentially an interference phenomenon; the minuteness of a point image, and therefore the clearness of definition, depending on the size of the object-glass. But he pointed out that if the aperture was limited to slits at opposite edges—so that no actual image anything like the object would be formed, but only the interference bands which the beams from the two slits could produce—a study of those bands would enable us to infer about the source of light very much more than we could get by looking at its image. For example, suppose it was a close double star, and suppose the slits over the object-glass were movable, so that they could be approached nearer together, or separated the whole distance of the aperture apart. A gradual separation of the slits would now cause the fringes to go through periods of visibility and invisibility; and the first disappearance of the fringes would tell us that the distance apart of the two components of the star (multiplied by the distance between the slits and divided by the distance of the star) would equal half a wave-length of light. The two components might be far too near together ever to be seen separately, and yet we could infer that the star was a double one; and by further attention to the visibility curve we could infer the relative brightness of the two components and their position relative to our line of sight.

Furthermore, if, instead of looking at a star, we turned the slit-provided telescope on a planet with a disc too small for ordinary measurement, the size of that disc could be estimated from the behaviour of the interference fringes produced by its light in a suitable interferometer, or by the telescope converted into one.

Michelson begins this 1890 paper thus:

"In a recent paper on 'Measurement by Light-waves' it was shown that the limitation of the effective portions of an objective to the extreme ends of a diameter converted the instrument into a refractometer; and although definition and resolution are thereby sacrificed, the accuracy may be increased ten to fifty fold.

"The simplest way of effecting this in the case of a telescope is to provide the cap of the objective with two slits adjustable in width and distance apart. If such a combination be focussed on a star, then, instead of an image of the star, there will be a series of coloured interference-bands with white centre, the bands being arranged at equal distances apart and parallel to the two slits. The position of the central white fringe can be marked from ten to fifty times as accurately as can the centre of the telescopic image of the star.

"One of the most promising applications of the method is the measurement of the angular magnitudes of small sources of light."

Michelson further realises, even at this early date, that by this method the virtual aperture of a telescope may be immensely increased by supplementing it by a pair of receiving mirrors beyond the object-glass, catching the light at 45°, and sending it towards the object-glass, where it is caught by two other mirrors, and sent down towards the eye. The interference-fringes now formed will be as if the two slits were separated by the whole distance of the outer mirrors apart. He then says that, by means of a right-and-left-hand screw, the mirrors are to be separated until the fringes disappear; when the angular diameter of the planet, if its disc is circular and uniformly illuminated, will be the ratio of a wave-length of light to the distance between the mirrors, multiplied by the numerical factor 1·22. This factor, it is interesting to note, was obtained by Sir G. B. Airy so long ago as 1834 (*Camb. Phil. Trans.*) as the appropriate number for a uniformly illuminated disc, when he was considering the resolving power of a telescope as dependent on the diameter of its object-glass. (See also Rayleigh, vol. i. p. 416.)

Michelson then goes on:

"The chief object of the method proposed is the measurement of the apparent size of minute telescopic objects, such as planetoids, satellites, and possibly star discs, and also double stars too close to be resolved in the most powerful telescope. . . . It would appear that a one-inch glass may be made to do the work now required of a ten-inch."

In view of the extraordinary and sensational interest which has been aroused by the recent application of this method by Michelson himself, with the aid of collaborators at Mount Wilson Observatory, Pasadena, California, and with the hundred-inch telescope established there, it may be interesting to quote here part of the conclusion of this paper of Michelson's of date 1890:

"(1) Interference phenomena produced under appropriate conditions from light emanating from a source of finite magnitude become indistinct as the size increases, finally vanishing when the angle subtended by the source is equal to the smallest angle which an equivalent telescope can resolve, multiplied by a constant factor depending on the shape and distribution of light in the source and on the order of the disappearance.

"(2) The vanishing of the fringes can ordinarily be determined with such accuracy that single readings give results from fifty to one hundred times as accurate as can be obtained with a telescope of equal aperture."

Then, after a few more clauses, comes this remarkable anticipation:

"If among the nearer fixed stars there is any as large as our sun, it would subtend an angle of about one hundredth of a second of arc; and the corresponding distance required to observe this small angle is ten metres, a distance which, while utterly out of question as regards the diameter of a telescope-objective, is still perfectly feasible with a refractometer. There is, however, no inherent improbability of stars presenting a much larger angle than this; and the possibility of gaining some positive knowledge of the real size of these distant luminaries would more than repay the time, care, and patience which it would be necessary to bestow on such a work."

There seemed little hope at that time, and certainly no reasoned expectation, that any stars, except perhaps some of the very nearest, could have discs big enough for perception and measurement even by this virtual telescope of thirty feet aperture. But in the course of the quarter of the present century through which we have lived, mathematical astronomers have been busy. When the history of recent stellar astronomy comes to be written, some living names such as H. N. Russell, Shapley, Eddington, and Jeans will shine as stars of the first magnitude. The possibility of giant stars—so named by Hertzsprung—has come above our mental horizon; and Eddington made the notable prediction that a star like Betelgeuse must be in a highly rarefied state at a tremendously high temperature, and that it would be swollen out by the pressure of light to a size almost comparable with the dimensions of a solar system, although it could not contain very much more matter than, say, two or five times our sun. His argument, in brief, is that the spectrum of a young red star like Betelgeuse shows that it cannot be radiating furiously. Why then is it so conspicuous an object to our vision? It can only be because it is of enormous size, its density perhaps a thousand times less than atmospheric air. By utilisation of the data available in the light of his theory of stellar constitution, Eddington made an estimate of the diameter of the star.

So with great skill Michelson and his collaborators got the interferometer to work. After many preliminary adjustments, on December 13, 1920, Dr. F. G. Pease at Mount Wilson, with Michelson's apparatus, measured the diameter of a star for the first time, using Betelgeuse for the purpose. The interference-fringes formed by the star were observed, the object mirrors were gradually separated, and it must have been a joyful moment when, as they grew farther and farther and farther apart, the fringes at the eye end became less distinct and ultimately disappeared. The distance apart of the mirrors now, multiplied by the proper fraction, gave the angular dimensions of the star—a thing which had never before been observed in the history of the world. An estimate of the star's distance gave its actual diameter, and confirmed Eddington's prediction!

Other stars have since been measured, and the giant stars well deserve their name. Moreover, an instrument has been put in the hands of posterity to the power of which we can scarcely set a limit in investigating utterly invisible details, both about the heavenly bodies and about atoms, by the new and powerful method of analysing the radiation which they emit.

The form of instrument adapted to the heavens is, however, not applicable to the atoms. The spectrum of atomic radiation is formed by a grating; and Rayleigh showed (see "Collected Papers," page 427, vol. i.) that the power of a prism spectroscope is expressed approximately by the number of centimetres of available thickness of glass, which is one form of saying that, to get high definition or separating power, we must use interference depending on a great number of wave-lengths retardation. The resolving power of a grating depends on its total aperture, which must always be limited to inches, since accuracy of ruling over the whole breadth is essential; but one can have retardation gratings, where the interference is caused, not merely by extra distance due to angular slope of path, but by the retarding effect of a dense substance, such as gelatine or something transparent, instead of by the successive obliterations or dark spaces of the grating. There would seem to be no particular advantage in that; but Michelson perceived that the retardation principle might be employed so as to make a grating which combined with its own effect the resolving power of a prism. A slab of glass a centimetre or more thick might be used to give the necessary lag in phase of many thousand wave-lengths, and thereby secure a definition and resolving power unthought of before.

So Michelson designed the Echelon spectroscope, consisting of thick slabs of glass, each protruding a millimetre or so beyond the other—a staircase spectroscope. When he brought this out in 1898 in the *Astrophysical Journal*, vol. 8, p. 37 (see also *Am. J. Sci.* and *Camb. Phil. Trans.* for 1898–99), it seemed as if such an instrument could scarcely be constructed, or, if it were constructed, that the number of slabs must be very few. But I understand that the skill of Messrs. Adam Hilger has sufficed to construct an Echelon with so many as fifty slabs; and this, or some similar Echelon, is now a regular instrument in the examination of the minute structure of spectrum lines. Naturally it cannot cover a great range of the spectrum; it has to be fed with light of a nearly definite refrangibility, and then it analyses the light, as a high-power microscope analyses a small range of visible structure.

The striking thing about all these instruments is that they give us, by inference, information about the invisible; and further developments are to be expected. For example, in connexion with stellar variation Prof. Shapley had proposed a theory of periodic pulsation, which would enable a single star to vary without an eclipsing companion; and this hypothesis was taken up by Eddington for the case of the Cepheid variables.

Subsequent repetition of the Mount Wilson interferometer-measurements on Betelgeuse, after an interval, seems to show that variations in diameter actually occur; and probably by this time much more information has been obtained than can here be summarised. But it illustrates the power of the instrument to confirm the indications of theory.

Before leaving this part of the subject it may be interesting to refer physicists to Paper 199 in vol. iv. of Rayleigh's "Collected Papers," also in *Phil. Mag.* for November 1892, in the form of a letter from Lord Rayleigh to Prof. Michelson about the interference bands of nearly homogeneous light.

I will only add further that Michelson has applied his instrument to examination of the Zeeman phenomenon, with inferences about the multiple character of many of the lines, as recorded in his paper on "Radiation in a Magnetic Field" (*Phil. Mag.* for July 1897 and April 1898).

References to Michelson's earlier papers on this subject are:

A general theory of interference-fringes in a refractometer, in *Phil. Mag.* for April 1882; a mathematical paper on the visibility of interference-fringes in the focus of a telescope, in *Phil. Mag.* for March 1891; on the application of interference methods to spectroscopic measurement, in *Phil. Mag.* for September 1892.

Now I find that I have omitted all reference to what is the popularly best-known work of Michelson, the application of his interferometer to determine if possible the motion of the earth through the ether. The speed expected was of the order one-ten-thousandth of the velocity of light; but since the journey of the light in the instrument is a to-and-fro journey—one half-beam going as nearly as possible with and against the hypothetical stream of ether, while the other half-beam goes at right angles to that direction—the amount to be measured was not one-ten-thousandth but the square of that quantity; that is to say, the observer had to measure one part in a hundred million—no easy matter. The apparatus has been so often described, and the theory so often given, that there is no need to say much about it. The interferometer was mounted on a stone slab floating in mercury, and the whole observation conducted with great care. The result was zero; and that zero was used afterwards as the corner-stone of the great and beautiful edifice of relativity.

That so extensive a structure should have been initiated by a zero result is philosophically curious, and shows great faith in the trustworthiness of the experimenters, Michelson and Morley. I am told that Morley, before he died, was rather overawed by the consequences deduced from that experiment, and was anxious that it should be repeated with still greater care, and under many conditions, some of which were indicated in their early paper (*Phil. Mag.*, December 1887), entitled "On the Relative Motion of the Earth and the Luminiferous Æther," by Albert A. Michelson and Edward W. Morley. For even then they suggested, on page 459, that perhaps at moderate distances above the level of the sea, or at the top of an isolated mountain peak, the relative motion might be perceptible.

Such repetition has, as we know, lately been attempted, with results which at present seem too unlikely to be credited; but as Prof. Miller's experiments are *sub judice*, I will say no more about them. I know that Michelson agrees with me (or did in 1920) that there was nothing in the original Michelson-Morley zero result to justify a denial of the existence of the ether; nor is a positive result necessary to re-establish it. The theory of relativity (so called) has led to a search for *absolute* conditions, independent of accidents of motion, the same for all observers; and this search for the absolute will continue, being justified by its brilliant success, quite apart from the corner-stone which is still part of the structure. On the whole, the theory rather tends to strengthen our philosophic conviction of the ether as an integral and absolute ingredient in the universe, although, for purposes of calculation and attainment of results, it—like many other things—can be safely ignored.

I append references to such papers as were published in the *Phil. Mag.* on other subjects, for the convenience of any who would like to look at them:

"Note on an Air-Thermometer" (September 1882); "A Method for Determining the Rate of Tuning-Forks" (February 1883); "On the Relative Motion of the Earth and the Luminiferous Æther"—the first Michelson and Morley paper (December 1887); "On a Method of making the Wave-length of Sodium Light the Actual and Practical Standard of Length" (December 1887); "A New Harmonic Analyser"—Michelson and S. W. Stratton (January 1898); "The Velocity of Light" (March 1902); "The Relative Motion of Earth and Æther" (December 1904); a short mathematical paper on "Diffraction" (April 1905); "On Metallic Colouring in Birds and Insects" (April 1911).

OLIVER LODGE.

Discovery and Dialectics.

Science and Scientists in the Nineteenth Century. By the Rev. Robert H. Murray. Pp. xvii+450. (London: The Sheldon Press; New York and Toronto: The Macmillan Co., 1925.) 12*s.* 6*d.* net.

DR. MURRAY, who is rector of Broughton and is distinguished as a historical writer, says: "In a sense my book forms an assault upon science, or to put it more correctly, upon the preconceptions that lie at its base far more than most F.R.S.s are aware." It is therefore permissible that a review of it in this journal should be, in a sense, a reply; for the book is very well written, it is interesting to read, and its data are culled from a wide range of the annals of men of science themselves; hence what one must call its misconceptions are likely to impress themselves upon a fairly wide public. On the other hand, there is a great deal in it from which scientific readers cannot fail to draw a very salutary lesson.

The virtue of the book lies in the emphatic warning, well hammered home by numberless examples, against pooh-poohing new ideas. The treatments of Jenner, J. Y. Simpson, Lyell, Joule, Darwin, Pasteur, and Lister by their contemporaries, together with less familiar and more briefly handled cases, are adduced in evidence of the futility of—may one coin a word?—Pooh-poomposity and the shut mind. It is a most valuable sermon on personal faults. Dr. Murray deplores the spending of time and energy which is exacted from discoverers by their need to silence hostile criticism, criticism which has turned out to be incorrect in the end, and has sometimes been rancorously expressed. No one defends personal rancour, whether it is *pro* or *contra* ; " a man may be a champion for truth without being an enemy to civility " ; and the same holds concerning cocksure affirmations and denials out-of-hand. Whilst a lay listener often mistakes philosophic emphasis for personal antagonism when it is nothing of the kind, it remains perfectly true that there are little minds and ignoble minds among men of science as everywhere else, and there always will be. Moreover, no man of science, not even the greatest, has more than a short period in his life during which he is so free from human vanities that his discoveries are faultless and his opinions just.

To Dr. Murray, as a student and a curator of human nature, it has evidently been a disappointment to find, from his reading, that these things are so ; but he has allowed them so to prey upon his mind, that he draws conclusions about science itself which are much too cheerless. For Dr. Murray, an admirer of great investigators, makes far too little of the real part which doubt plays in science. Even a great investigator is liable to be affected by the Idols of the Tribe and of the Cave, and when his admirers cavil at adverse conservatism, they are guilty of a worse heresy than are those whom they blame. Although the author does not omit to make mention of this, the tenor of the whole book is undoubtedly to cause it to be ignored by the reader. Scepticism is the great promoter of intellectual progress ; and if every plausible idea had received general approval at its birth, or even general tolerance, the effect would have been chaotic—as, indeed, is indicated by the passage from Thucydides which Dr. Murray rather inconsistently quotes as the text of his book. No discovery is actual until it has been widely put to the test, for no discoverer ever sees all round his problem ; and the result—one had almost said, the purpose—of opposition is to provoke the originator to make his claim good and better, by more observation. The onus of proof is on the discoverer : he is held guilty of misstatement unless he can clearly show the contrary ; and in this ruthless but reverent safeguarding of truth lies the strength of the scientific method, not (as our author appears to think) its shame. Dr. Murray actually makes it a complaint that the man of science is " a dour deevil to convince " ; of course he is, and if he had not been, there would have been no science ; and the whole dour generation of them must be convinced before the new thing can become the true thing.

There are several matters wherein the author's vivacious biographical accounts might easily lead to a wrong impression. Jenner's opponents were mostly medical practitioners, not men of science ; also, though Jenner was proved right about vaccination in the end, he had given a handle to critics, at the time when he had only a *prima facie* case, by having made rash inferences in other fields of study. Again, J. Y. Simpson's opponents were not men of science, they were surgeons ; and they contested anæsthesia on ethical rather than on logical grounds, for while he urged that pain is wrong, they thought it natural and salutary. Not dissimilar remarks apply to Lister and antisepsis. As to Lyell in geology, Dr. Murray himself admits that " it was part of the good fortune of Sir Charles Lyell that he had suffered much from opposition." Concerning a problem studied by Darwin which had, unknown to him, been investigated before, is it ever true that a scientific research has been " done once for all " ? On Joule and the conservation of energy, to say that Kelvin was " blinded by preconceived notions " is surely a little disrespectful to the vast knowledge of massed facts which is dismissed as " preconceived notions " ? Was one research, by one man, to be allowed to change the face of all that Kelvin then knew ? More experiments were what he asked for.

The important point that is missed by Dr. Murray, in common with most laymen, is that a research or an idea which can be achieved by one man alone has no standing as a truth in science. We are not as trustful of our own powers as that. When enough people have arrived at the same point, when the new thing has become a statistical experience and no longer an individual experience, then only is it authentic. This is an integral part, it would seem, of the canons of modern scientific proof. The process is like cupellation : the button of rich metal is purged of its dross in the fire of scepticism, and the golden bead of truth remains. Looking back, we see that a proved scientific truth is, in fact, something rather less than the greatest common factor of the current scientific beliefs on the question ; it is to be found midway between those who believe too quickly and those who believe too slowly ; and inevitably in due time it prevails, and it begets fresh truths. The business is certainly cumbrous and almost painfully slow—especially to those who cannot take part in it—because so many of us, being human, are as stupid as any of our lay brothers. But the process seems nevertheless to " get there " far more rapidly and more surely than does any other mode of inquiry.

Dr. Murray uncovers without concealment the axe which he has to grind. " One main purpose," he says, " in writing this book has been to prove that there are just as many preconceived notions in science as there are in theology " ; and later he adds that his book stands or falls largely by this thesis. He gives us, however, only one side of his equation, for we are not given the corresponding washing of the theologians' linen; and it strikes the unsophisticated scientific reader as a very cynical and despairing warrant for his line of argument when the author says: "In logic two blacks do not make a white, but in life they sometimes do." Apart from these merely dialectic comments, there remains one cardinal error, which vitiates the whole thesis: namely, to decry what lies at the base of science simply because its students are apt to go outside the scientific method. One might as well argue: "Some plumbers are socialists; I do not believe in Socialism; therefore a system of sanitation must be a bad thing." Science is the discovery of things, not a society of persons.

The layman who reads this book would probably be led to fall into the same pit as its author, confusing investigators with what they help to discover; and the book is thus a poor guide for him. To scientific readers it forms a powerful sermon on good manners; it is a large collection of interesting personalia; and it can be recommended accordingly. Irvine Masson.

Popular Science.

(1) *Electricity and the Structure of Matter.* By L. Southerns. (The World's Manuals.) Pp. 128. (London: Oxford University Press, 1925.) 2*s.* 6*d.* net.

(2) *The Story of Electricity from Thales to Einstein.* By W. F. F. Shearcroft. (Stories of Science Series.) Pp. 73. (London: Ernest Benn, Ltd., 1925.) 2*s.* 6*d.*; stiff cloth, 3*s.* 6*d.*

(3) *Readable School Electricity.* By Vivian T. Saunders. (Bell's Natural Science Series.) Pp. xii+176+8 plates. (London: G. Bell and Sons, Ltd., 1925.) 2*s.* 6*d.*

(4) *The Electron: its Isolation and Measurement and the Determination of some of its Properties.* By Prof. Robert Andrews Millikan. (University of Chicago Science Series.) Second edition, second impression. Pp. xiv + 293. (Chicago: University of Chicago Press; London: Cambridge University Press, 1924.) 9*s.* 6*d.*

(5) *Die Evolution des Geistes der Physik 1873–1923.* Von Prof. A. D. Chwolson. Aus dem Russischen übersetzt von Prof. V. R. Bursian. Pp. vi+197. (Braunschweig: Friedr. Vieweg und Sohn, A.-G., 1925.) 10 gold marks.

IF the output of the publishing press is a valid criterion, there is as yet no abatement of the wave of popular interest in physical and, in particular, in electrical science. Electricity is very much in the air at present. Schemes of electrification on a gigantic scale are advocated in Parliament and in the press. Above all, "wireless" receivers with their inductances and capacities, their metres and wave-lengths, and their valves, which brightly or dully glowing make the set not infrequently more pleasant to watch than to listen to, have brought the mysteries of electrical science on to the domestic hearth. It is not surprising that there are a considerable number of people who would like to know, if it can be managed without too much mental labour on their part, what electricity is and how it works. That such a demand really exists is proved by the statement of one of the authors of the volumes enumerated above, that he has been induced to produce the present volume by the hearty welcome to a former book on similar lines.

The demand is not an easy one to satisfy. The book must be cheap (there seems to be some unanimity among publishers that its price should be 2*s.* 6*d.*), for the desire to know is not one of those imperious passions which must be satisfied at any price. It must not require much from the reader in the way of concentration, or active thought. It must be attractively written and well illustrated, with photographs rather than diagrams, for diagrams are cold and repellent to all except the real enthusiast. In addition, the author will, in order to satisfy his own conscience, wish the book to convey some genuine knowledge to the reader, and to produce in his mind impressions which are not too unlike the actual facts. It is, of course, this last self-imposed condition which makes the writing of these books so difficult.

(1) Of the first three books on the list above, we think that "Electricity and the Structure of Matter" by Mr. Southerns is the most successful. Mr. Southerns has selected his material well, and shows, in his treatment of it, a light and deft touch. He possesses a fine sense of showmanship, which in the illustration where the author's pen pauses a moment to be X-rayed, rises almost to genius. He will probably find, however, that the X-ray installation figured in the frontispiece will work more satisfactorily if he connects in the condenser. The book is most attractively illustrated and produced, and can be recommended warmly to any reader in search of a pleasant and not too profound account of modern electrical science.

(2) In comparison "The Story of Electricity" by W. F. F. Shearcroft is dull, and in spite of its dullness is distinctly less informative than the preceding volume. To attempt to deal with relativity in five small pages, and with the quantum theory in three, is asking for trouble. With the author's obvious desire to illustrate the nature and methods of scientific progress by a history of one of the sciences we have every sympathy. An excellent book might be written on these lines. It is not, however, a thesis which can be adequately developed in 62 pages of text.

(3) "Readable School Electricity" stands on a somewhat different footing from the two volumes already noticed, as it proclaims itself as being specifically a school book, one of the newer type based on the thesis that the object of a school book should be to stimulate the interest of the beginner, in the hope that, when his interest is stimulated, he will himself demand to be taught the grammar of the subject, so necessary to any true knowledge, but at the same time inevitably so dull. This is a thesis on which school masters and university teachers are apt to hold divergent views. The author of the present volume is not an extreme supporter of the thesis, and though the book deals mainly with applications of electricity, it is by no means entirely superficial, and there are scholarly touches which are most welcome in a school book on science.

(4) and (5) If any justification is possible for including in one and the same notice the volumes we have just dealt with and the two that remain for review, it must be that whereas the former represent a fair average of what popular science is, and perhaps must be at the present time, the latter are bright and shining examples of what it may become when a true interest in science for its own sake, and a real appreciation of its aims and discoveries, have become more general than they are as yet. The fact that Dr. Millikan's classic "The Electron," after running through nine impressions in eight years, has now reached a second edition, of which the copy for review is part of a second impression, would, however, seem to give grounds for hope that this educated public is not even now so small as we might, in atrabiliar moments, be inclined to believe; and will, we hope, encourage authors and publishers to give us more books of the same stamp. To praise such a book as "The Electron" is superfluous. Dr. Millikan is well known to be as skilful with his pen as in his laboratory. We need only add that the new edition contains fresh matter which brings his account of his subject well up-to-date, and readers of the first edition will certainly wish to see it.

Prof. Chwolson's scholarly volume "Die Evolution des Geistes der Physik 1873–1923" raises questions far too complex to be dealt with at the tail end of an omnibus review. He has been a close and not unfriendly observer and critic of the progress of physics throughout the period with which he deals. He believes that the last fifty years have seen not merely a growth in the content, but also a change in the spirit of the subject, which it is the object of his book to demonstrate. The book is thus more than a résumé—it is a criticism; and to a science suffering somewhat from a surfeit of its own discoveries, and inclined a little, perhaps, towards swelled-headedness, a friendly dose of cold water may be not merely salutary but even welcome. Many students who have profited from Prof. Chwolson's monumental text-book will at least be glad to have his matured opinion of what they have done with their instruction. We should welcome an English edition of this thoughtful little book. Should some kindly publisher be willing to increase our indebtedness to himself by placing an English version on his list, we hope he will not be misled by the title of this article into classifying it as popular science.

Physico-Chemical Problems of the Cell.

La cinétique du développement: multiplication cellulaire et croissance. Par Dr. E. Fauré-Fremiet. (Les problèmes biologiques.) Pp. viii+336. (Paris: Les Presses universitaires de France, 1925.) 35 francs.

As its title indicates, this book deals with the problems of development from the point of view of changes in the energy potential and the physico-chemical constitution of the animal organism. A very wide field is covered embracing the experimental aspects of embryology and cytology, and the very numerous and various facts presented are, by the method of treatment, welded into one consistent whole. Apart from its originality of outlook, the book is undoubtedly of great value to all experimental biologists merely as a work of reference. The author's solution of the problem of what to omit will probably, in the main, meet with approval. It is at first sight strange to dismiss in a short footnote (p. 114) the evidence for the permanency of the chromosomes, but as information on this point is readily available in numerous text-books, the author has perhaps chosen wisely in omitting it here. The omission of any discussion on regeneration, with the exception of a short account of the healing of wounds, is more to be regretted. The problems of regeneration and those of development are undoubtedly closely allied, and the scattered facts and theories of regeneration could well bear such a critical review as the author has, in this book, bestowed upon other problems.

The first three chapters deal, broadly speaking, with the physico-chemical constitution of the cell, and the changes therein, during growth and division, and to a large extent may be said to be based on Zwaardemaker's conception of the application of the phase rule to the problem of protoplasmic structure. The author admits frankly that in the present state of our knowledge the application of this rule can be only tentative. This conception has been used with admirable discretion, and perhaps its main virtue is that it has enabled the author to link together in one connected and extremely interesting whole the very considerable number of facts and theories here presented. Perhaps too much mystery is made of the nucleus-cytoplasm volume relationship; the discussion of this would have been greatly simplified by beginning from the obvious consideration that materials for nuclear growth can only reach the nucleus by first passing through the cytoplasm. Indeed, it may be regarded as certain that the raw food materials of the cell are not available for use by the nucleus until they have been very considerably altered by the cytoplasm. Obviously, then, after division of a cell there must be a lag in the rate of growth of the nucleus of the daughter cell as compared with its cytoplasm, since, except for the possible persistence of small quantities of nuclear "food" in the cytoplasm of the daughter cell, the nucleus has to wait for its supplies of food material until these are elaborated by the cytoplasm. Many, though not all, of the various changes in the nucleus-cytoplasm volume relationship are explicable in this simple manner. A minor point of criticism in this chapter is that the table given on p. 90 is by no means clear until reference is made to the footnote on p. 92. As it stands, the table will be taken to show the number of cells developing from a fertilised Strongylocentrotus egg in a given time at various temperatures, and proves little beyond the obvious fact that at low temperatures development is less rapid. The comparison intended is between larvæ of the same degree of morphological evolution reared at various temperatures, and shows that at low temperatures the larvæ contain fewer cells and relatively larger nuclei than larvæ of an equal degree of morphological differentiation reared at higher temperatures.

Chapter 4 deals with the very difficult subject of energy transformations during embryonic development. This chapter suffers somewhat from a plethora of cold facts, and is apt to leave the non-specialist with no very clear ideas on the subject. The blame for this may perhaps with more justice be laid on the subject than on the author, as the study of the energetics of development has as yet scarcely emerged from the chaos and multiplicity of disconnected facts which is the necessary but unpleasant beginning of most sciences. The remaining three chapters deal respectively with growth in metazoa, multiplication of Protozoa, and growth in tissue cultures. The chapter on Protozoa is, of three good chapters, the best, and provides a most excellent summary of its subject. In the chapter on tissue culture, the author is to be congratulated on having included such things as the healing of wounds and the growth of grafts, and on having shown the relationship of these phenomena with those of tissue culture *sensu stricto*.

The mathematical treatment adopted in many places throughout the book will be regarded by the non-mathematical biologist as a painful necessity, and to such may give some little difficulty. In some of the tables of figures the author has omitted to state the units to which his figures refer. Though reference to the context usually clears up this point with little difficulty, the omission is none the less annoying. But whatever minor faults this volume may contain, it is not only a fine work of reference, but also has in an eminent degree the still higher excellence of originating fresh ideas, suggesting new experiments, and fortifying that modern conception of biological inquiry the adherents of which are striving little by little, with progress however slow and doubtful, towards the ultimate goal of raising biology to the rank of an exact science; of explaining "vital" processes in terms of physical and chemical units.

J. G. H. F.

The American Coal Commission.

What the Coal Commission Found: an Authoritative Digest and Summary of the Facts about Coal. By Staff Members. Edited by Edward Eyre Hunt, F. G. Tryon, and Joseph H. Willits. (Human Relations Series.) Pp. 416. (Baltimore, Md.: Williams and Wilkins Co.; London: Baillière, Tindall and Cox, 1925.) 25*s*. net.

THE need for a careful study of the many difficult problems presented by the coal industry led to the appointment towards the end of 1922 of the United States Coal Commission, which continued to function for eleven months, during which time it spent about 120,000*l*. and employed at one time more than 500 persons. The very voluminous records and findings of the Commission have been conveniently condensed in the present volume of a little more than 400 pages, in which are collected together the important portions in an eminently readable form. Its appearance at the present moment is particularly important in view of the fact that we, too, have a Coal Commission now sitting for the purpose of studying the same industry in Great Britain, and the findings of the American Commission will assuredly afford some useful guidance, though it is obvious that the problems in the two countries are in many respects widely different.

In the United States the essential problem is how to ensure an uninterrupted supply of coal to the industries and the people generally; in Great Britain the problem is how to bring down the cost of production of coal to such a level as to enable British collieries to compete successfully in the world's markets. America is to some extent indifferent to the cost of production, because America is a self-contained country, producing within its own borders everything that is needed for the nation's well-being. In Great Britain, on the other hand, the cost of production is the dominating factor, because it is only by means of coal produced sufficiently cheaply to enable it and the various articles, for the manufacture of which it is indispensable, to be sold at competitive prices in the markets of the world.

In spite of this wide divergence in the character of the problems, it becomes evident upon investigation that the underlying causes which have given rise to them are very similar. The findings of the American Coal Commission are therefore not without their value for British investigators. It must, however, be pointed out that the American Commission has been careful to distinguish between bituminous coal and anthracite, and that it is only the former portion of the subject that finds any counterpart in Great Britain. Perhaps the most interesting sentence in the book is the record of the finding of the Commission that there is "no reason to believe that a dependable supply of coal at a reasonable price is inconsistent with reasonable conditions of life and citizenship for the miners, or with a reasonable return on judicious investments." In order to attain this most desirable consummation a number of recommendations were made, though it appears to have been fully recognised that, in the words of John Hays Hammond, who contributes a foreword to the volume, "There is no easy panacea for the troubled industry."

The most important recommendations were those addressed to the industry itself, and these include the development and efficient application of mechanical devices to replace hand loading, better control and co-ordination of underground operations, standardisation and co-ordination of the work of the individual mine-worker, standardisation of details of construction and dimensions of all mine equipment. In respect of Government action, the recommendations are mainly negative; thus compulsory arbitration and nationalisation of the mines were not recommended. Curiously enough, the British wage agreement, the termination of which has precipitated our coal crisis, comes in for approval. Finally, the fact is stressed that this is not a question to be fought out between the colliery owners and the coal miners alone, but that the public is vitally interested, and this last statement is even more profoundly true in Great Britain than in the United States. Hence comes the need for the public to receive authentic and unbiassed information on all matters concerning the coal industry, so that "guided by facts rather than rumours, by information rather than prejudice, the people will be able to exercise wisely the powers of the Government over this type of private business."

H. Louis.

Our Bookshelf.

(1) *Laboratory Manual in General and Pathogenic Bacteriology and Immunity.* By Prof. Veranus Alva Moore and Prof. William Arthur Hagan. Pp. xii+252. (Boston, New York and London: Ginn and Co., 1925.) 8*s.* 6*d.* net.

(2) *Bacteriology: a Text Book on Fundamentals.* By Prof. Stanley Thomas. Pp. xiii+201. (New York: McGraw-Hill Book Co., Inc.; London: McGraw-Hill Publishing Co., Ltd., 1925.) 12*s.* 6*d.* net.

(1) The first of these books is intended to be a laboratory guide on bacteriology for veterinary students. It consists of practical exercises, and at the end of each exercise is a series of questions. The latter seem uniformly to have little or no bearing on the particular exercise. Thus Exercise No. viii. is headed "Making plate cultures: the Gram stain," but it contains no information about the Gram stain. Nevertheless, the student is asked the question at the end of the exercise, "What is the function of the iodine solution in the Gram technic?" The only answer to this question which we can find in the book is given in Exercise vii., in which it is stated that "little is known of the chemical process involved in the Gram stain." This kind of sample has not been particularly selected. It occurs more or less throughout the book. English examiners would not cordially accept an answer like this from a candidate.

(2) The second book is by Stanley Thomas, who is associate professor of bacteriology in Lehigh University, Bethlehem, Pa. It is a general account of bacteria and their actions. It is well written, covers a good deal of ground, and is for the most part accurate. The author's statements on the history of bacteriology require correction, and his chapters on pathogenic bacteria indicate that he is not so much at home with them as when he deals with bacteriology applied to public health.

The Strength of Materials: a Treatise on the Theory of Stress Calculations, for Engineers. By John Case. Pp. viii+558. (London: Edward Arnold and Co., 1925.) 30*s.* net.

The book under notice differs somewhat in its purpose from the usual text-books on the subject, in that little space is given to discussion of the physical properties of materials or to experimental work. On this account the author's sub-title, "The Theory of Stress Calculations," is perhaps more appropriate, expressing more correctly the scope of the work. The sequence adopted for the various branches of the subject is open to criticism, but the theoretical treatments covering a wide range of problems of real importance to the engineer are very complete, except in some of the more advanced portions of the work, as for example in the account given of the torsion of non-circular shafts, where the results of the theory are stated only.

In the later portion of the book a treatment is given of the temperature stresses in thick cylinders, and in view of its importance, the more general problem of the stresses in cylinders and discs due to any concentric temperature distribution, on the lines of Prof. C. H. Lees' work, might well have been included as it presents no great difficulties. A good abridged account of Prof.

C. E. Inglis's work on the transverse oscillations of beams is given, but the chapter on the whirling of shafts is scarcely satisfactory, as no account of this subject in a modern treatise can be so considered which omits to take account of the general question of the stability of the motion and the factors which govern it. The whole is none the less a welcome contribution to engineering literature. The numerous references to various authorities contained in the footnotes are not the least valuable feature of the book, and, in addition to sets of good examples at the ends of the chapters, a large variety of interesting and instructive practical examples are worked out in the text. E. H. L.

Air Ministry: Meteorological Office. The Weather Map: an Introduction to Modern Meteorology. By Sir Napier Shaw. (Published by Authority of the Meteorological Committee.) Sixth issue. (M.O. 225i.) Pp. 112 + 8 plates + 8 charts. (London: H.M. Stationery Office, 1925.) 1*s.* 3*d.* net.

THIS publication was first issued in 1916 for the benefit primarily of those who were making use of meteorology in the War. The work has naturally grown, although only slight alterations are made in the present issue. A note on visibility has been added. The book is of the highest possible value to those who wish to obtain an intelligent interest in the weather and its numerous and complicated changes. The author, who has done much to place meteorology in its present position among the sciences, has achieved an immense success in placing modern meteorology so thoroughly and so simply before his readers. With the extensive broadcasting of the weather forecasts, many are wishful of obtaining an intelligent insight into the construction of the weather map and the weather changes indicated. The sequence of the weather is dealt with, and simple types are given showing the influence of time on changes of weather, winds, temperature, and pressure. Tables and maps are given for the reduction of the observations and show the average or normal conditions of the several elements for the whole or any part of the British Islands. A chapter is given on the upper air; it is stated that the world's height record in an aeroplane is 39,587 feet, achieved by M. Callizo on October 10, 1924, at Villacoublay near Paris. The highest mountain climb was achieved by the climbing party on Mount Everest, seen on June 8, 1924, at a height of 28,230 feet. The ballon-sonde has enabled temperature observations to the height of 22 miles, and on many occasions up to 12 miles.

(1) *The New Matriculation Geometry.* By A. G. Cracknell and G. F. Perrott. Pp. x+303. (London: University Tutorial Press, Ltd., 1925.) 4*s.* 6*d.*
(2) *A School Geometry on "New Sequence" Lines.* By W. M. Baker and A. A. Bourne. (Cambridge Mathematical Series.) Pp. viii+307. (London: G. Bell and Sons, Ltd., 1925.) Books 1-3, 2*s.* 6*d.*; Books 1-5, 4*s.*

THE teachers who objected to the introduction of a "new sequence" in geometry on the grounds that it would merely mean the exchange of Euclid's yoke for another scarcely less objectionable, have evidently some justification for their fears. Both these books give no less than 120 propositions to cover the substance of Euclid I.-IV., in addition to which the former dismisses similar figures in 10 pages, and the latter deals adequately with the propositions of Euclid VI. and XI. Surely some of these 120 propositions could with advantage be treated as riders or, at any rate, a clear distinction should be made between propositions which the pupil is supposed to reproduce and those he is merely asked to understand.

It is interesting to note that the method of superposition flourishes as if nothing had been said to its detriment during the past twenty years.

The riders in both books are good and numerous, but in "The New Matriculation Geometry" the bulk of them are collected together at the end of the book.

Leitfossilien: ein Hilfsbuch zum Bestimmen von Versteinerungen bei geologischen Arbeiten in der Sammlung und im Felde. Herausgegeben von Georg Gürich. Vierte Lieferung: Leitfossilien der Trias. Wirbellose Tiere und Kalkalgen, von C. Diener. Pp. ii+118+28 Tafeln. (Berlin: Gebrüder Borntraeger, 1925.) 24 gold marks.

THE publication of this useful work on characteristic fossils has extended over a long period. Part 1 (Cambrian and Silurian) was issued in 1908; part 2 (Devonian) in 1909; part 3 (Carboniferous and Permian) in 1923. The portion recently published deals with the invertebrates and calcareous algæ of the marine Trias, and has the inestimable advantages of being the work of Prof. C. Diener, whose researches on Triassic cephalopods are known to all geologists and palæontologists. The treatment of the subject is strictly systematic; in each group of fossils the characters of the families and genera are given, with notes on some of the important species. The work is illustrated by numerous figures, mainly copied from the memoirs of recognised authorities, but those of the calcareous algæ are from original drawings by Dr. Julius Pia. Short but useful bibliographies are given for each group of fossils. The work concludes with tables showing the stratigraphical divisions, and the ranges of the characteristic fossils, in all the principal regions of the world where the marine Trias is developed. It is to be regretted that this part, like parts 1 and 2, is without an index.

The Mathematical Theory of Electricity and Magnetism. By Dr. J. H. Jeans. Fifth edition. Pp. viii+652. (Cambridge: At the University Press, 1925.) 21*s.* net.

THE fifth edition of an established text-book calls for little comment. The previous edition was marked by the introduction of a new chapter on the theory of relativity. The present volume has yet another new chapter on "The Electrical Structure of Matter," intended as an introduction to the quantum theory. It seems rather sad that this new chapter should have to confess that some of the conclusions in the earlier part of the book—as to the radiation of energy from an accelerated electron—are in contradiction with modern knowledge, and that the whole theory which led to those conclusions is in need of amendment; but such is the history of science. The chapter will admirably serve its purpose of leading up to modern theory.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Transmutation of Elements.

A Transmutation of Lead (First Method).

SINCE the publication of my letter in NATURE of October 25, 1924, on the transformation of elements, I have continued the experiments in collaboration with Dr. A. Karssen.

The quartz lead-lamp, after being altered several times, was finally given the following definite construction (Fig. 1). The two legs are bent upwards, and the lower ends of one of the steel electrodes, one of which is provided with a piece of carbon, are ground to a tight joint into the legs, so that they can serve as cocks. The electrodes are connected with the legs of the lamp in a completely air-tight manner without the use of mercury. This lamp, containing, of course, also a storage vessel, is mounted on a stand provided with a wide copper tube with a series of gas burners to keep the lead in the lamp in a molten condition.

Further, the lamp is provided with two other copper tubes connected with a conduit pipe from the compressed air supply to cool those parts of the lamp which are heated too highly by the electric arc.

In our experiments we had to consider the possibility of the transformation of lead into mercury, which makes it desirable, of course, to avoid the use of a mercury air-pump and a mercury manometer. Therefore, the lamp initially was evacuated by a carefully cleaned metallic pump, connected with two U-tubes, placed in liquid air, and finally with a large vessel filled with coconut charcoal, also cooled in liquid air, by which method a high vacuum could be obtained. If not working in vacuum the pressure was measured by a glass spring manometer provided with a calibrated scale. Working under pressure, the connexion with the coconut charcoal vessel was broken, and pure nitrogen was admitted.

It is evident that in researches such as are mentioned here, the material used must be as pure as possible. The firm of Kahlbaum was so kind as to prepare for us an extra pure preparation of lead with the utmost care to prevent every contamination, especially by mercury vapour. In this preparation neither mercury nor thallium could be detected analytically.

The quartz parts of the lead lamp were cleaned by a solution of potassium dichromate and nitric acid, then steamed, and then finally heated to redness in a current of dried air. The metallic parts of the lamp, made of steel, after cleaning were heated to redness and the carbon valve underwent exactly the same treatment. *All these materials, examined spectroscopically, were shown to be completely free from mercury and thallium.*

The method of investigation used by us was as follows: After filling the storage vessel, the lamp and the lead were heated in high vacuum to redness. The lead oxide being dissociated, the liquid lead was as brilliant as mercury. Then the lead was brought into the lamp, and after ignition the spectrum was observed at 25 volt and 36 amp., by a Hilger quartz-spectrograph. Further, the spectrum of a quartz mercury lamp was observed, and also the scale in such a way that, to facilitate comparison, the different spectra were adjacent. Thus we obtained the spectrum of the lead in its initial state. After that we burned the lamp at 40 amp. and ±80 volt for 10 hours. After having done this the lead was poured into the storage vessel to obtain thorough mixing; the lead was then brought into the lamp again, and after ignition the spectrum was observed at 25 volt and 36 amp. The result was that, whilst initially the lead spectrum showed only very weakly the mercury line 2536 in the ultra-violet, after 10 hours' burning the strongest mercury lines had appeared in the visible as well as in the ultra-violet part of the spectrum, and also the most characteristic thallium line, indicating a transmutation of lead into mercury and thallium.

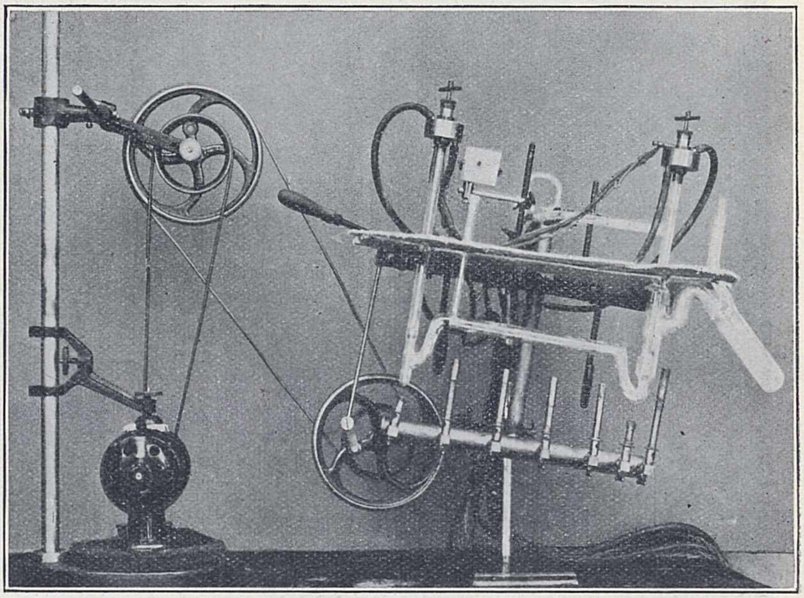


FIG. 1.—Quartz lead-lamp.

Since our experiments showed that a high current density is very favourable to this transformation, we used currents up to 60 amp., but that seemed to be dangerous, because only by intensive air cooling could melting of the quartz-lamp be prevented.

We thought it better, therefore, to change our method a little, by applying not a continuous electrical current but sparks of high current densities. Therefore, the lead lamp and the delivery tube with gas burners, and the cables and cooling tubes, were all mounted on the same stand, turning on a horizontal axle. While the lamp was kept oscillating by a mechanical arrangement as shown in Fig. 1, a current of high density was breaking and making. At make the current was 60-100 amp., and since the last contact is made by a very thin spout of liquid lead, the current density on the moment of breaking the current will be exceedingly high. This method was very successful. Since at the places where sparks are emitted a black film appears, it was necessary before observing the spectrum to clean the quartz tube as well as possible by burning the lamp half an hour continuously. After that the lead was poured into the storage vessel and then again into the lamp, as already mentioned; the spectra obtained now showed a much stronger transmutation, and after $9\frac{1}{4}$ hours' sparking all mercury lines, even the very weak ones, were present.

Our purpose, of course, was to see what the result would be after continuing our experiments a very long time. In this case, however, we met a great difficulty, since the quartz became corroded strongly by the lead, forming a film of lead-silicate, blackened by silicon.

To make us independent of the formation of this film, at the place where the arc in the lamp is formed a quartz tube (observation tube) of 15 cm. length and 8 mm. diameter was sealed, the upper end of which was provided with a flat bottom.

The light of the arc passing through the unattacked quartz-bottom, reflected by a nickel mirror, was directed to the quartz-spectrograph. Fig. 1 shows the observation tube and the nickel mirror. By this means the transmutation can be studied so long as the lamp stands.

Fig. 2 shows the results. The mercury spectrum is in each case placed above the lead spectrum. Fig. 2A shows the mercury spectrum at the top, and at the bottom the spectrum of the extra pure lead in the initial state. It is seen that this lead preparation is very pure: the lead spectrum does not contain mercury lines. The negative being always a little more distinct than the prints shows a very weak indication of the mercury line 2536, that is, the line which always appears in our experiments first.

Burning and sparking we obtained successively the photographs reproduced above as Fig. 2. 2B was after burning half an hour at high current density; 2C, after $2\frac{3}{4}$ hour sparking; 2D, after $8\frac{3}{4}$ hour sparking; 2E, after 12 hour sparking; and 2F, after 39 hour sparking.

We see in photograph 2B the green and the indigo mercury line, and some lines in the ultra-violet have already appeared. The line 2536 is strongest. The double yellow mercury line is not yet present. In 2C more mercury lines have appeared, and the lines already present in 2B have become much stronger. The double yellow mercury line has also appeared. In 2D and 2E the mercury lines are distinctly prominent over the lead lines in the lead spectrum. To make the results as convincing as possible the time of exposure in photographing the lead spectra was 20 minutes in the case of 2A and 2B, 15 minutes in the case of 2C and 2D, and 10 minutes in the case of 2E. Finally, in the case of 2F, the exposure was only 3 minutes, and now we see that the lead lines in the visible part of the spectrum have disappeared, and in the ultra-violet the lead lines have weakened. The mercury lines, however, are very distinct along the whole spectrum.

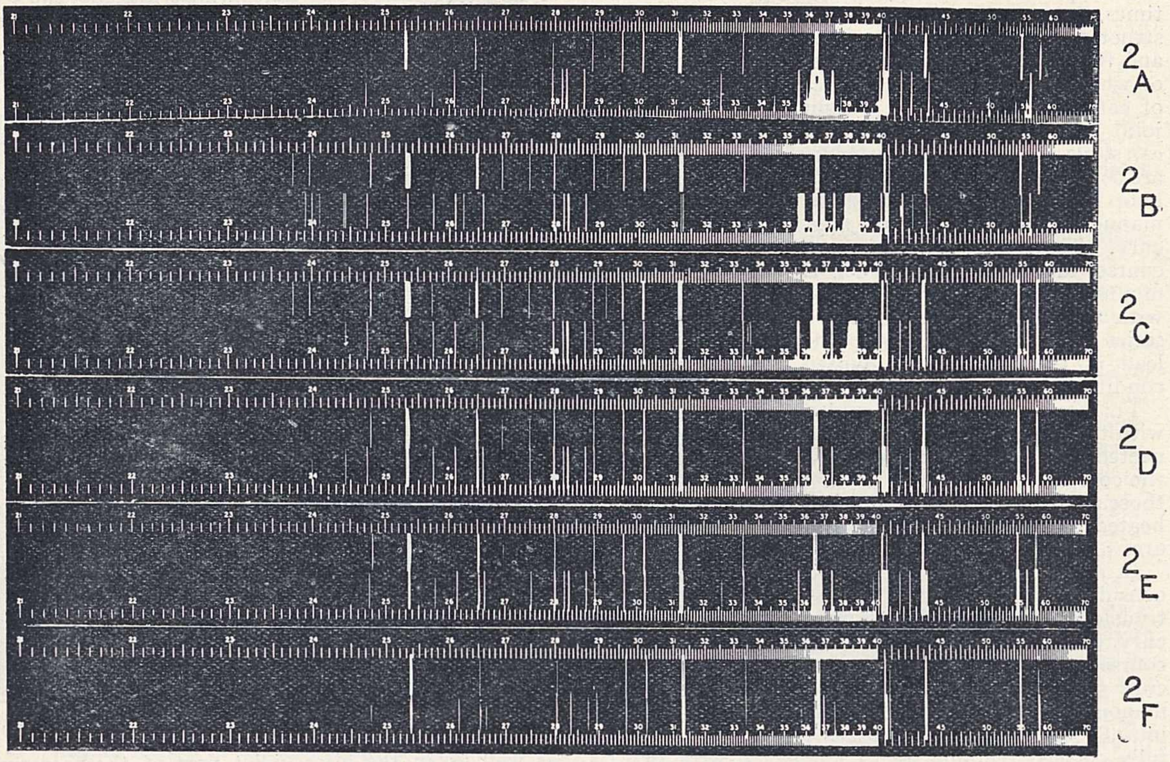


FIG. 2.—Spectra of lead with comparison spectra of mercury, the upper spectrum in each case being that of mercury. (Some of the very faint lines have not appeared in the reproduction.)

This, however, does not yet prove the transmutation to be strong, as it is known that a relatively small quantity of mercury can cause the spectrum of another element to disappear. But at all events our spectra show in a very convincing way the transmutation of lead into mercury. As to the thallium lines, it is very remarkable that these lines appear only if the spectrum is photographed directly, that is to say, not using the observation tube, but pointing the light emitted by the lamp directly to the quartz-spectrograph. This seems to be connected with the fact that thallium, like lead, is taken up by the quartz. So we state that the formation of a film of lead silicate results in a stronger lead spectrum if observed directly. This phenomenon will be referred to in another place.

A Transmutation of Lead (Second Method).

After having shown the transmutation of lead by the method mentioned above, we applied another very successful sparking method. Extra pure lead supplied by Kahlbaum was heated in a quartz tube up to about 800° for an hour, whilst a current of pure nitrogen was bubbled through. We thus obtained a lead preparation comparable with the lead in our lead lamp, in which it was heated to this temperature in a high vacuum. From the lead obtained in this way, two lead electrodes of 14 mm. diameter were made. Between these electrodes, mounted vertically at a distance of about 4 mm. apart in a vessel with a liquid dielectric, sparks at a voltage of 100,000 volt and 2 milliamperes were sent through the liquid for 12 hours.

The dispersed lead was partly at the bottom and partly in colloidal solution. The fine lead at the bottom of the vessel was collected, washed successively in pure benzene, alcohol, and ether, and finally dried in a desiccator. The metal in the colloidal solution was converted into nitrate by treating the liquid with pure nitric acid at 100°.

After evaporating the aqueous solution on a water bath, the nitrate was placed in a desiccator.

Both substances were examined. The method of analysis was substantially a method of Jannash (*Z. für Anorg. Chemie*, 12, 143 (1900)), as modified by us. Mercury eventually present is driven out by heating in a current of air and condensed in a glass capillary. Then iodine vapour is conducted over it, forming with mercury the red modification of the compound HgI_2. This extremely sensitive reaction, if applied to the electrodes as prepared by us from the extra pure Kahlbaum lead, showed that these electrodes were completely free from mercury, but the dispersed lead obtained by sparking in the circumstances mentioned showed a very distinct mercury reaction.

Consequently, also by this second method, the transmutation of lead into mercury could be realised.

Whether thallium is also formed is being examined.

Both methods mentioned above will be applied soon to bismuth, thallium, and other elements to be considered here.

In another letter we propose to give the results of the quantitative analyses and some theoretical considerations.

A. SMITS.

Laboratory of General and Inorganic Chemistry,
University of Amsterdam,
November 29.

Selective Action of Polarised Light upon Starch Grains.

THE letter of Prof. E. C. C. Baly and Dr. E. S. Semmens in NATURE of December 5, p. 817, on the selective chemical action of polarised light upon starch grains seems to me to raise a question of fundamental importance for optics. Is it possible to reconcile such an action with received views about the kinematic relations of polarised light?

Let us begin by considering a case where difficulty does *not* arise. Baly and Semmens refer to Padoa's observation that "crystals of *o*-nitrobenzaldehyde are selectively decomposed by polarised light, *provided that the crystals are correctly oriented to the plane of polarisation*" (my italics). I have not had the opportunity of consulting Padoa's paper, and know nothing of the details; but there is no obvious *a priori* reason why such an action should not occur: for the molecules in the crystal are all similarly oriented, and may well be less able to withstand a displacement in one particular direction than in the perpendicular one.

It is easy, however, to pass to a case where the difficulty does arise. Suppose the crystal pulverised, and the fragments shaken up so as to be oriented at random. They cannot now be all favourably oriented to the polarised beam. Some of them, on the other hand, will be more favourably oriented to a beam polarised at right angles to the first; and if both beams were present, they would presumably add their effect. We can get the two beams instead of one by simply *removing the polariser*, or, in other words, using unpolarised light. It seems clear that in this case polarising the light (with inevitable loss of half of the intensity) must *diminish* the chemical action. The same reasoning seems to apply with equal force to the case of the starch grains, assuming that these are oriented at random.

Great caution is required in weighing any *a priori* reasoning against what seems the result of direct observation. Both, however, involve the human element, and both are therefore liable to be wrong.

RAYLEIGH.

Terling Place, Chelmsford,
December 14.

IT was with much interest that I read the letter relating to the action of polarised light on starch hydrolysis contributed to NATURE of December 5 by Prof. Baly and Dr. Semmens. This letter, since the writers refer to a short "note" by myself in the *Annals of Botany* (July 1925), calls for a brief reply.

Prof. Baly and Dr. Semmens are, like myself, under misapprehension. I desired to call in question, not the possibility of the phenomenon occurring, but the trustworthiness of the evidence put forward by these authors in their paper (*Proc. Roy. Soc.*, 97 B, 250, 1924). The fact that a large amount of evidence in favour of the occurrence of this phenomenon may have been published by the authors or others elsewhere appears to me to be of great interest but quite irrelevant in so far as objection is taken to the "note" for which I was responsible. For example, Weigert's observations on the effect of polarised light on the photographic plate do not make me any readier to believe that potato starch grains in weak diastase solution, after four hours' exposure to polarised light, as a result of hydrolysis will present the appearance shown in Fig. 3, Plate 12, in the paper criticised. I am also dreadfully puzzled to understand why this figure, described in the text as showing "hydrolysis obtained with light polarised by a Nicol prism," was published, if it was not intended as evidence. The "complete disappearance of the grains" I have not observed with potato starch even after some days in strong diastase solution: in my experience a kind of "starch shell," which does not give a blue colour with iodine, persists obstinately.

Since an experiment of my own is cited (which was additional to a repetition of any described by the authors) in which a gelatine film was used, I may perhaps point out that the starch grains were resting on the surface of the gelatine, which was used merely as a convenient adhesive surface to prevent the grains from moving about, and that the polarised light reached the grains without passing previously through the gelatine film. But I should regard any such experiments that give a negative result as of little importance compared with one conclusive experiment of which the result was consistently positive: and no doubt Prof. Baly and Dr. Semmens will agree with me in this. The position remains unsatisfactory, however, until the reason for the negative result receives satisfactory explanation.

As one who has suffered from the painful effects of traversing in full sun snowfields in the Alps, I was interested to learn that this effect was due to "the well-known influence of polarised light." I do not feel, however, that an argument of the form—"certain effects are produced by light on crossing a snowfield—some of this light is polarised—therefore the effects are due to the polarised light"—will withstand logical analysis.

W. NEILSON JONES.

Bedford College,
Regent's Park, N.W.1.

The Occurrence of Dwi-Manganese (At. No. 75) in Manganese Salts.

As the present writer is responsible for the polarographic investigations of solutions containing dwi-manganese (see letter by Dolejšek and Heyrovský, NATURE, 116, p. 782), he alone replies to the criticism of the above letter by Mr. A. N. Campbell (NATURE, 116, p. 866). This criticism shows a misunderstanding of what the polarographic-electro-analysis with the dropping mercury cathode really means. First of all, the present author's potentials refer, as expressly stated, to the calomel—not absolute—zero, and thus, of course, do not agree with those obtained by Mr. Campbell, since the present author's special electrolytic method is based on an almost currentless reversible electrolysis which differs widely from ordinary electrolytic methods (see, for example, *Tran. Far. Soc.*, 19, p. 692, 1924; *Rec. Trav. Ch. Pays-Bas*, 44, p. 488, 1925). The over-voltage on the pure mercury cathode beads is so large that hydrogen begins to be deposited from a deci-normal hydrionic concentration at − 1·20 v. from the calomel electrode (*Rec. Trav. Ch. Pays-Bas.*, 44, p. 503, 1925), and at the acidity of the solutions used in the dwi-manganese investigations, at − 1·3 v. to − 1·4 v., *i.e.* far behind the point of deposition of element 75. Variation of hydrion concentration from 0·1 n. to neutral solution produced no effect upon the "75" hump, neither was its shape or position affected by polarising the sulphate or the chloride. Solutions of manganese sulphate which were freed from the two impurities by means of the electro-chemical deposition described in the first letter showed no hump whatever before the deposition potential of manganese at − 1·35 v.

Solutions were further obtained by subliming volatile chlorides from a fraction rich in "75," and these showed on polarograms the corresponding humps without any manganese in solution. The formation of manganese tetrachloride at the large mercury anode used in this method is out of the question, and it is equally impossible to superpose an alternating current with this delicate arrangement.

Polarograms of sodium sulphate have been frequently studied (*Rec. l.c.*, p. 493, 600), and show the same flat curve as those for sodium chloride, bromide and hydroxide.

Altogether about 400 polarograms were obtained, by the author and five collaborators working on three different pieces of apparatus in the dwi-manganese research, and checked by polarising solutions containing additions of different metallic salts to ensure that the new hump was due to a metal not hitherto identified. Whenever this hump is very prominent, the *L* lines of element 75 invariably appear in the X-ray spectra obtained by V. Dolejšek, and the combination of the two methods is now used as a guide in the analytical enriching of the solutions in element 75. Finally, the "75" hump agrees well with the deposition potentials at the dropping mercury cathode expected for the triad 25, 43, and 75, since in all analogous examples the deposition potentials of the metals in a triad become more positive by 0·1 v. to 0·2 v. with increasing atomic weight.

For a better understanding of the above explanations Mr. Campbell is referred to the seventeen papers dealing with this special electrolysis already published in English, and particularly to the Brauner jubilee number of the *Rec. Trav. Ch. Pays-Bas*, 44, pp. 488-600.

J. HEYROVSKÝ.

Institute for Physical Chemistry,
The Charles' University, Prague,
December 15.

MR. A. N. CAMPBELL in his letter to NATURE (Dec. 12) questions the validity of Dolejšek and Heyrovský's conclusions (NATURE, Nov. 28) that the second "hump" in their manganese deposition curve is due to the presence of small amounts of dwi-manganese.

In his letter Mr. Campbell assumes that the Czech authors used a platinum cathode, whereas it was Heyrovský's "dropping mercury cathode." As Mr. Campbell does not appear to be acquainted with Prof. Heyrovský's apparatus, I should like to direct his attention to an account of it in the Brauner jubilee number of the *Recueil des Travaux Chimiques des Pays-Bas* (May 1925). In his general introduction to a series of researches with this apparatus, Prof. Heyrovský pointed out, with examples, that the method he used was capable of detecting impurities down to concentrations of 10^{-6} gram-equivalents per litre. This has not been controverted.

Dolejšek and Heyrovský's interpretation that the "hump" in their manganese deposition curves was due to traces of dwi-manganese in "pure" manganese sulphate is supported by the isolation of the oxide of the new element from manganese sulphate and chloride by Mr. F. H. Loring and myself (*Chem. News*, Oct. 30, Nov. 27). By an entirely independent method we have been able to obtain about a gram of what we believe is fairly pure higher oxide of dwi-manganese.

Prof. Heyrovský's "dropping mercury cathode" does not appear to have received in Great Britain the attention it merits, although the writer of the section on general and physical chemistry in the Chemical Society's "Annual Report," 1924, mentions in connexion with it (p. 21) that there is no indication of a surface film being formed on it. This would invalidate Mr. Campbell's contention.

GERALD DRUCE.

December 14.

The Plant as a Measure of the Habitat.

IN NATURE of October 31, p. 656, appears a note concerning the plant as a measure of the habitat, wherein reference to "The Phytometer Method in Ecology," by Clements and Goldsmith, is made.

The subject of the complexity of the individual plant as a recorder is correctly touched upon, and opinion is expressed that probably it will be long ere physical instruments can be dispensed with in plumbing the possibilities of the environment.

As workers in phytometry have been comparatively few, and are almost entirely American, it may be worth while to record very briefly indications as to the utility of the phytometer, obtained by me as the result of independent work.

South African native tree seedlings (*e.g.* those of *Ocotea bullata*, *Olinia cymosa*, *Olea laurifolia*, *Platylophus trifoliatus*, *Cunonia capensis*) are being tested as phytometers, the growth and transpiration responses under both natural and artificially produced habitats receiving initial attention. The results so far are distinctly favourable to the use of the plant as habitat measure; a short and preliminary account is to be published in the near future. For the forester, phytometric cultures, either free or under control, seem likely to prove valuable in returning information regarding the habitat as it impresses itself upon the plant, in throwing light on practices and processes either detrimental or conducive to the production of the optium yield from particular localities, and in indicating the species best suited to the areas to be planted.

By many it is realised that the most elaborate measurement of the physical factors of the habitat by instrumental methods usually does not even approximately inform the investigator as to the nature of that habitat as it influences the living plant itself. The plant is the truest measure of the effects of the complex produced by the integration of the several habitat factors. Provided that points of such importance as the careful selection of suitable types of plants, the employment of large numbers of individuals so that abnormal ones can be eliminated, and the study of the several responses of the plant in conjunction with physical apparatus, receive careful attention in the first instance, it does not seem too optimistic to believe that, with increased knowledge of the behaviour of selected species, the phytometer of itself will give intelligible quantitative information as to the nature of the habitat.

The value of the phytometer for analyses of habitat and vegetation processes alike is likely to be as great as the study of this grand subject is alluring.

JOHN PHILLIPS.

Forest Research Station,
Deepwalls, near Knysna, South Africa,
November 21.

The Principal Series of the Copper Arc Spectrum.

THE second pair of the principal series of the arc spectrum of copper has been calculated by Randall (*Astro. Jour.*, 34, 1, 1911) as 2025·73 and 2024·42 (Rowland scale). Kayser and Runge (Kayser, "Handbuch der Spectroscopie," vol. 5) observed only one line at 2025·08 (I. Å.), while two lines in this region have been photographed by Rubies (*An. Soc. Esp. Y Quim*, 15, 432, 1917), and their wave-lengths given in Fowler's Report on Series in Line Spectra as 2025·1 and 2024·11 (presumably on the Rowland scale). Shenstone (*Phil. Mag.*, 49, 951, 1925) in his low voltage arc work found only one line and gives its wave-length as 2024·33.

Recently in this laboratory photographs of the arc spectrum of copper under varying conditions have been taken on several large quartz spectrographs. The dispersion of these instruments at λ 2025 is approximately 0·8 mm. per Ångström unit. The exposures taken varied from 15 to 30 minutes. The current strength of the arc was 3 amperes on a 220 volts circuit.

When the middle of the arc was projected on the slit of the instrument, the 2024 line alone was recorded. When the whole image of the arc was projected, both lines were recorded, but the 2025 line was shown at the poles only. In all photographs the 2024 line was shown reversed. A plate of the spark spectrum showed only 2025. This agrees with Hasbach's spark work.

Independent calculations were made from photographs taken on three separate instruments. Interpolations were taken from a Hartmann formula based on the lines 2043·71, 2035·74 and 1999·95 (Hasbach, Kayser and Konen's "Handbuch der Spectroscopie," vol. 7). The values of the 2025 line agreed to 0·01 and those of the 2024 line to 0·02. Schumann plates were used. The following table contains our measurements, together with other known values. All wave-lengths are reduced to I. Å.

TABLE I.

	λ.	λ.	$\Delta\nu$.
Randall (calculated) . .	2024·33	2025·67	32·7
Kayser and Runge . . .	..	2025·08R	..
Rubies	2024·05	2025·04	24·1
Shenstone	2024·33	..	..
Hasbach	..	2025·36	..
Simeon and Dreblow .	2024·19R	2025·34	28·1

Our observed value of $\Delta\nu$, which is not expected to be in error by more than $\pm$1·0, is notably less than Randall's calculated value.

From the results given above it is concluded that the 2024 line is a true arc line, being reversible and present in the centre, that the 2025 line is a spark line, and that therefore they do not constitute the second pair of the principal series.

F. SIMEON.
E. S. DREBLOW.

Research Laboratory, Adam Hilger, Ltd.,
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London, N.W.1,
November 19.

The Action of Silica on Electrolytes.

OWING to absence from the laboratory during the summer, I have only recently been able to make experiments on the effect of silica on acids, using silica prepared as described by Prof. Mukerjee in his letter to NATURE of August 29. The silicon tetrachloride was added to water in a silica dish and the mixture dialysed until the specific resistance rose to 120,000 ohms. It was then dried at the air temperature without the use of any desiccating agent. I have been unable, however, to detect in this product the slightest adsorbing power for hydrochloric acid. In his letter of April 4, Prof. Mukerjee gives figures from which I infer that he found that silica could take up more than 1 per cent. by weight of hydrochloric acid. I used one gram of silica and 100 c.c. of N/500 acid and should easily have detected the adsorption of less than 0·0004 gram hydrochloric acid (*i.e.* 0·04 per cent. by weight) by the conductance and *p*H measurements used. But not the slightest sign of removal of hydrochloric acid from solution was obtained.

I do not know whether Prof. Mukerjee has modified his views since April 4, as in his last letter the only experimental evidence suggested is that it is easier to remove traces of hydrochloric acid from silica by means of potassium nitrate solution than water. This is a very different matter from that which has been under discussion, and I will not take up space with a consideration of the various possible explanations. I am only concerned with the direct question as to whether or not pure silica can remove acids from solution, and I have been unable to obtain any evidence that it is able to do so.

One point has to be borne in mind when making these experiments: silica, prepared as above and partially dehydrated, retains much moisture (mine contained 20 per cent. after air drying for a week), which may dilute quite noticeably the solution to which it is added, and I have always corrected for this. The correction may be important in some cases, although in these experiments the quantities of reagents have been chosen so that it is very small.

A. F. JOSEPH.

Wellcome Tropical Research Laboratories,
Khartoum, November 10.

The Evolution of the Stars.

By J. H. JEANS, Sec. R.S.

ABOUT a year ago (NATURE, December 6, 1924) reasons were given for supposing that the source of stellar radiation is to be found in the annihilation of stellar matter. Subsequent investigation suggests that the same hypothesis can clear up the puzzle of stellar evolution and of the spectral changes of a star.

In the early days of stellar spectroscopy, the spectrum of a star was believed to be an index to the star's age. That the spectra of different types of stars showed lines of, say, hydrogen, calcium, and titanium oxide, was explained by the supposition that as a star aged, its composition changed, by transmutation of the chemical elements, from hydrogen into calcium, from calcium into titanium oxide, and so on. We know better now; the researches of Saha and others have shown that a star's spectrum is an index only to the temperature of its surface. The solar spectrum shows calcium lines merely because the sun's outer layers happen to be at a temperature at which calcium atoms are very active in absorbing and re-emitting radiation; if the temperature of these layers were suddenly doubled, their spectrum would consist mainly of hydrogen lines, while if the temperature were halved, the spectrum would be dominated by the titanium oxide bands. The various types of spectra might quite well be expressed merely as temperatures, except for some outstanding difficulties as to the correct calibration of the temperature scale. Thus the problem of explaining the spectral changes of a star reduces to that of tracing out the sequence of temperatures assumed by its surface.

When we attempt to interpret radiation in terms of the annihilation of matter, the first observational fact that confronts us is that the radiations of the stars are nothing like proportional to their masses; for example, the very hot star V Puppis radiates nearly 1000 ergs a second for each gram of its mass, the sun about 2 ergs, and the earth certainly less than $\frac{1}{10000}$ erg. The transformation of matter into radiation clearly proceeds at very different rates in different bodies.

Our first impulse is perhaps to conjecture that the rate of transformation may be expedited by high temperature. But considerations of stability are found to prohibit any substantial effect of this kind. We can see in a general way that if a rise of temperature resulted in more rapid transformation, then any slight local excess of generation of energy, by raising the temperature, would force a still greater excess generation of energy, and so on without limit. Precise mathematical investigation (*Monthly Notices, R.A.S.*, October 1925, p. 914) shows that the observed stability of the stars permits of at most a very slight increase of this rate of transformation with temperature, and even this seems to be ruled out by physical considerations. Since matter is atomic, its annihilation must also be atomic, the annihilation of the smallest unit, a proton and electron, producing 0·0015 ergs of energy. This will form one quantum of radiation of wave-length $1{\cdot}3 \times 10^{-13}$ cm., which corresponds to a temperature of 7,500,000 million degrees. The temperature of a star's interior, some ten or twenty million degrees, is perfectly insignificant by comparison, and must be deemed quite incapable of affecting the process of transformation either way, at any rate by direct methods. We must accordingly suppose that matter is transformed into radiation by a spontaneous process, which proceeds, like radioactive transformations, without any regard to temperature or density. Newly generated radiation will have a wave-length of $1{\cdot}3 \times 10^{-13}$ cm. or less, but will soon become "softened" by interaction with matter and will degenerate into ordinary temperature-radiation before it has travelled far through a star. Part of the radiation generated in astronomical bodies of very low density may, however, escape into space as "hard" radiation of wave-length of the order of 10^{-13} cm.; this may be the origin of the highly penetrating radiation recently investigated by Millikan.

The great range of values of radiation per unit mass cannot, then, be traced to the variations in the physical conditions of different stars; to account for it we have to suppose that stars consist of a mixture of different types of matter which radiate at different rates, and that the proportions of the mixture vary from one star to another. Those types of matter which radiate most energetically are, of course, also those which annihilate themselves most rapidly, and so are the first to disappear as the star gets old. A young star, containing a greater proportion of these types than an old star, ought to emit more radiation per unit mass. This is in actual fact observed to be the case. Our sun, then, radiates less energy per unit mass than V Puppis simply because it is seven million million years older, and in this interval the elements which are responsible for most of the radiation from V Puppis have disappeared from the sun.

Since the process of transformation is a spontaneous one, it follows that if we know the composition of a star at birth and the rate of transformation of each of its constituent types of matter, we can trace out the changes in its composition throughout its whole life; the problem is similar to that of tracing the changes of radioactivity in rocks. Knowing the star's constitution at each instant of its life, we can, of course, deduce its rate of emission of radiation.

A mathematical study of the conditions of stellar equilibrium (*Monthly Notices, R.A.S.*, January, March, and June 1925) shows that the mass M, rate of emission E, and surface-temperature T of a spherical star in equilibrium are connected approximately by an equation of the form

$$2\tfrac{1}{2} \log E = \phi(M) + c \log T + \text{a constant}, \qquad (1)$$

where $\phi(M)$ is a function of the mass, which is roughly proportional to $\log M$.

If this equation were accurately instead of only approximately true, the problem of tracing a star's evolution would be very simple. Corresponding to any assumed composition of the star at birth we can, as we have just seen, trace out the sequence of changes in the mass M and the emission E. At each instant the star will adjust itself so as to be in equilibrium by selecting a surface-temperature T such as to satisfy equation (1). The value of T given by this equation must accordingly determine the star's spectrum at every instant and the problem is solved.

It may seem almost incredible that the theoretical solution of the problem of stellar evolution should be so amazingly simple, yet such appears in actual fact to be the case, except for certain secondary complications, five of which we now discuss. These secondary complications impart incident and richness to the problem; it is because they intervene just where observation shows them to be needed, and because

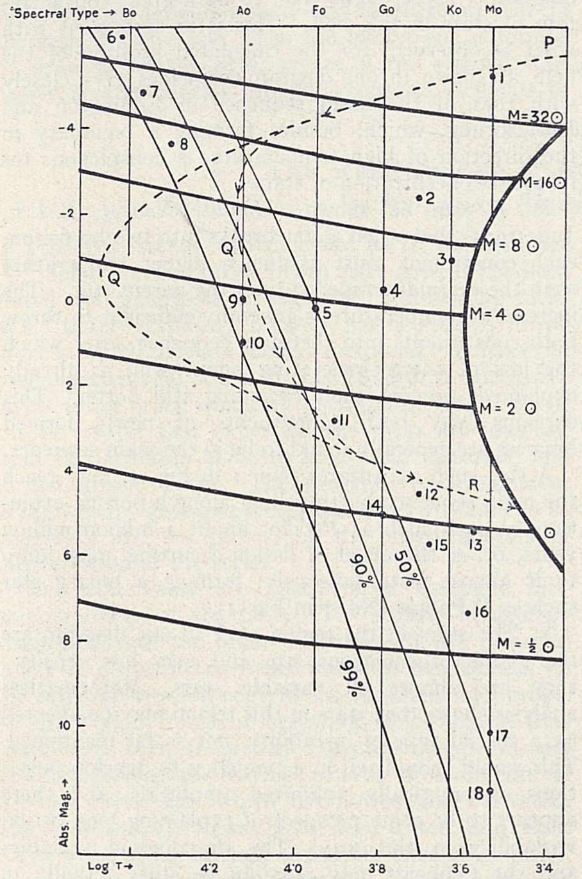

FIG. 1.—The stars, which are those shown by Russell in his diagram in NATURE (August 8, 1925), are as follows: 1, Antares; 2, δ Cephei; 3, Arcturus; 4, 5, Capella; 6, Plaskett's star; 7, V Puppis; 8, Y Cygni; 9, β Aurigæ; 10, Sirius; 11, Procyon; 12, 13, α Centauri; 14, Sun; 15, 16, ξ Bootis; 17, 18, Kruger 60.

they give just the requisite modifications to the main solution, that we can feel confidence in the latter.

I. Equation (1) is based on the conception of a star's interior put forward by the present writer in 1917, according to which the atoms are very largely disintegrated, as a result of high temperature, into their constituent electrons and nuclei, these now playing the rôle of "molecules" in the quasi-gas of which the star is formed. If the temperature were so high that every atom was completely disintegrated, equation (1) would be strictly accurate, c probably being equal to 2, the value given by Kramers' and Eddington's formulæ for stellar opacity. Actual stars are not so hot as this, so that c is somewhat less than 2. For average stars like our sun the value of c appears to be about unity, while for still cooler stars c may be negative.

Now the investigation of the star's dynamical stability shows that a configuration is stable (within limits to be mentioned later) if c is positive, but is definitely unstable if c is negative. A star becomes unstable as soon as it has cooled so far that c becomes negative.

The solution of equation (1) may be exhibited graphically as in Fig. 1. In this diagram $\log T$ and $-2\frac{1}{2}\log E$ (the star's absolute magnitude) are taken as horizontal and vertical co-ordinates. Equation (1) gives a value of M corresponding to each point in the diagram, so that each point represents a configuration of equilibrium for a star. The hottest stars are to the left of this diagram, the coolest to the right; the most luminous (which are also the most massive) are at the top, both mass and luminosity decreasing as we pass downwards. If c were strictly constant and positive, the curves along which M has constant values would be a series of parallel straight lines slanting upwards to the left. When the slight variations in c are taken into account, these lines run in the way shown by the thick lines in the diagram, the unstable parts for which c is negative being omitted. The thick curve on the right passes through the points at which c changes from positive to negative and so marks the limit between stable and unstable configurations.

Every astronomer will at once grasp the significance of this curve and of the hole it makes in the range of stable configurations. In 1913 Hertzsprung showed that the M-type (or red) stars fall into two clearly divided classes—stars of high luminosity which he called giants on account of their great size (a large surface-area being necessary to discharge so much radiation), and stars of low luminosity, the dwarfs. Between these two groups of stars lay a great gulf. Later, Russell, Adams, and others showed that the gulf extends to other spectral types, probably up to about $K4$. The theoretical curve which bounds the region of instability in our diagram cannot be drawn with great accuracy, but there seems little room for doubt that it must coincide with the boundary of the gulf between the giants and dwarfs. If so, there is a very simple reason for this gulf; stars cannot exist inside it because they would be unstable.

II. Every point of the diagram shown in Fig. 1 represents an equilibrium configuration for a star; as a star's evolution proceeds its representative point moves, and its evolutionary career can be recorded by a curve. On tracing out mathematically the evolution of a typical star in the way already explained, the evolutionary curve is found to be roughly parabolic and oriented like the dotted curve PQR in the diagram. The temperature of the star first increases until it attains a maximum at Q, then turns and decreases continuously, precisely as described by the "ascending and descending temperature" series of Lockyer. In time the star runs into the region of unstable configurations, as at R in the diagram.

When this happens, the star's internal generation of energy has become inadequate to supply its loss by radiation. Ordinarily a star would remedy this by expanding or contracting, but in this particular instance the star is already in a configuration in which its loss by radiation is a minimum, so that any change, whether in the direction of expansion or contraction, merely increases the rate of loss which is already too large. Equilibrium is no longer possible, and the star has to make good the deficiency in its generation of radiation by drawing upon its store of gravitational potential energy. It contracts rapidly.

The fundamental equation (1) was derived on the supposition that the gas pressure inside the star conforms to Boyle's law. The gas-molecules are, however, free electrons the diameters of which are far smaller than those of true molecules, whence it results that the stellar gas can shrink to enormously higher densities than ordinary gas before Boyle's law begins to fail. Eddington has suggested that this probably gives an explanation of the amazingly high densities observed in the stars known as "white dwarfs." The surfaces of these stars are at high temperatures and their radii so small that their densities must be thousands of times that of lead. The star the career of which we are following, when once it has become unstable, must continue to shrink until Boyle's law no longer holds even for those absurdly small molecules, the free electrons. It becomes a white dwarf.

Thus our scheme of stellar evolution demands white dwarfs and provides a niche into which they fall naturally and inevitably. At the same time it suggests views of the physics and evolution of the white dwarfs which differ somewhat from those hitherto held. Eddington and Russell have considered the white dwarfs merely as extreme cases of ordinary stellar configurations. That the two or three white dwarfs so far detected are comparatively similar to one another must, on their view, be regarded as accidental. Our theory, on the other hand, implies that the white dwarfs form a separate and detached colony; they ought all to be rather like one another, and there should be no continuity with ordinary stars. As regards their evolution, the white dwarfs have been described as the oldest stars extant, "vestiges of an earlier creation," and so on. Our view of their evolution implies that they are neither older nor younger than the great majority of stars; they have merely been more unfortunate. The white dwarf state is a sort of bankruptcy court into which a star falls when it is unable to make both ends meet in the matter of radiation. When the original Sirius broke up into Sirius *b* and Sirius *f*, the former contrived to keep most of the matter which was easily transformable into radiation, hence the present splendour of Sirius *b* and the unhappy condition of Sirius *f*. In such cases as α Centauri and Kruger 60 there appears to have been a fairer division of radiation-producing material.

III. The typical evolutionary path *PQR* in our diagram penetrates regions near *Q* in which no stars are found. A star at *Q* would have practically all its atoms stripped bare of electrons, while calculations on actual stars show that very few have more than about 95 per cent. stripped bare. (The slant lines in the diagram show the proportion of bare nuclei calculated for an assumed atomic number 20.) The obvious interpretation of the observed facts is that in some way the evolutionary paths are turned before they reach regions of, say, 99 per cent. of nudity.

If the annihilation of matter is a quantum process of the kind I originally conjectured (NATURE, December 6, 1924) this would happen automatically, for the baring of each nucleus would represent a loss of energy-generating power, and a star with all, or too many, of its nuclei stripped bare would leave off generating energy until sufficient atoms had re-formed. The typical evolutionary path in our diagram must no longer be taken to be *PQR*, but some such path as *PQ'R*.

The belt of configurations in which, say, from 80 to 99 per cent. of the nuclei are bare forms a sort of common envelope to most of the evolutionary tracks in the diagram. There ought then to be a great concentration of stars in this belt. This is in agreement with what is observed, for the calculated position of the belt, as shown in our diagram, coincides very closely with that of the main sequence of Eddington and Hertzsprung, which, besides forming a boundary in the direction of high temperature, is conspicuous for its great concentration of stars.

IV. It can be shown (*Monthly Notices, R.A.S.*, June 1925) that when a star breaks into two by fission, each constituent must assume a higher temperature than the original temperature of the parent star. The increase of temperature is generally sufficient to throw both constituents into the main sequence, after which the loss of energy-generating power will, as already explained, prevent their becoming still hotter. This explains why both constituents of newly formed binaries are generally found to lie in the main sequence.

A star such as Antares (No. 1 in Fig. 1) may reach the main sequence by travelling along a normal evolutionary path such as *PQ'* for about a million million years, or, in the event of fission occurring, may jump to it almost instantaneously, forming a binary star such as V Puppis (No. 7 in Fig. 1).

V. The stars in the region of *P* in our diagram are red giants of enormous size and very low density; they are almost all variable stars. Mathematical analysis shows that stars in this region may be affected by a special type of instability, not so far mentioned. This would show itself in a tendency to develop pulsations of practically unlimited amplitude, and there appears to be some prospect of explaining long-period variability in this way. The short-period variables and the Cepheids may possibly be stars actually in process of fission, as is suggested by their position in the diagram. Such conjectures need to be tested very thoroughly before they can be accepted, but it is at least clear that the proposed theory of evolution provides a place quite naturally for these two main types of a stellar variation.

Each of the foregoing modifications of the simple theory has been demanded by theoretical considerations, and each has been found to provide a natural, and almost inevitable, explanation of one outstanding feature of observational astronomy, as follows:

I. Giant and dwarf stars.
II. White dwarfs.
III. The "main-sequence."
IV. Early spectral types of newly-formed binaries.
V. Variable stars (conjectural).

It seems fair to say that no other theory of evolution gives a tenable explanation of even any one of these five features. This is the case for the proposed theory.

If a star, in breaking up by fission, divided its different ingredients proportionally between its two constituents, it is easily shown (*Monthly Notices, R.A.S.*, June 1925) that the fainter constituent would be of earlier spectral type than the brighter. This arrangement prevails in many newly formed binaries, but not in all (cf. Leonard, *L.O.B.* 343, 1923), and it is clear that in many cases, as in that of Sirius already discussed, the more massive constituent must have kept an undue share of highly radiating material; an extreme case of this kind is provided by the sun and earth. The situation is consistent with the supposition that the highly radiating material is of exceptionally high atomic weight and is therefore left in the more massive star when the lighter one is formed by drawing off the outer layers of the original star. Newly created matter probably contains elements of atomic weights far higher than any known on earth; it may even consist entirely of such elements. Our terrestrial elements are merely a residue of material which is practically non-transformable—dead ashes for the most part, although possibly the radioactive elements still retain some vestige of the powers of primeval matter. For one brief moment it seemed possible that cosmogony might teach us how to obtain almost boundless supplies of energy by the annihilation of quite insignificant fragments of matter, but this apparently is not to be. So far as we can at present see, Nature has arranged that the energy-producing elements shall be kept out of the reach of man; while he may watch the process of transformation going on in the stars, he will never be allowed to operate it himself. Whether this is to his advantage or disadvantage, who shall say?

The Relative Age of Rocks containing Fossils.

By Sir ARTHUR SMITH WOODWARD, F.R.S.

DURING recent controversies as to the evidence for the evolution of life in past ages, it has been stated that geologists arrange the fossil-bearing rocks in a "purely artificial" manner, not necessarily in the order in which they are found superposed. It has even been asserted that when the fossils occur in successive layers in an order which an evolutionist would say is the reverse of that expected, the rocks are assumed from this criterion alone to have been disturbed and turned upside down. The progressive development of life which a geologist recognises, indeed, is said to be imaginary and not proved by the observed order of superposition of the rocks.

Such statements are based on a complete misunderstanding of the facts. The science of geology originated, and the order of nearly all the principal layers of sedimentary rocks was first determined, on the unstable western edge of the continent of Europe. In this region from the beginning of geological time there have been frequently repeated downward and upward movements leaving records in sediments of the successive seas which overflowed and retreated. The sedimentary rocks have been tilted and their edges worn away in such a manner that their order, or relative age, is easily observed. Their succession in fact is so clear that it has been possible in several cases to follow the changes of material in one and the same layer—the sands and gravels which were deposited near the shore, the mud farther out, and the remains of calcareous skeletons forming limestone in the clear water of the open sea. As an illustration may be mentioned the lower Carboniferous deposits, which are open sea limestones in central England but gradually pass into estuarine sands and clays with beds of coal in the south of Scotland, where there are only occasional beds of limestone containing approximately the same fossils as the great marine deposits farther south. More than a century ago, when almost all naturalists believed in "special creation" and there were no accepted theories as to the order of "creation," the succession of the rocks in England and Wales was made out by William Smith from actual observation of their superposition. Later geologists merely elaborated details, and made more extensive collections of fossils. Geologists on the present European continent found the same general succession in their several countries, only varied by local circumstances; some additional layers being intercalated in the typical British series, others omitted, and some being represented by different rocks. Allowing for the differences in sediment and its amount which would be deposited in different parts of the same sea and adjacent estuaries, the succession was discovered quite clearly by observations in the field.

It was not until the field-work was far advanced that the fossils were studied in detail and found to indicate distinct progress in the development of life on the earth. None but animals without a backbone have ever been found in the oldest fossiliferous rocks; fishes are known to have flourished long before any lung-breathing backboned animals; the cold-blooded amphibians and reptiles came successively before the warm-blooded birds and mammals; man appeared at the end. In several groups, too, fossils collected from rocks of which the relative age is definitely known from observation of the layers in the field, show that the lower grades appeared before the higher grades. This became evident so long ago as 1836, when Buckland in his Bridgewater Treatise remarked on the interest of the oldest known mammals from the Stonesfield Slate of Oxfordshire as belonging to the lowly pouched group of marsupials. He stated that "the analogies afforded by the occurrence of the more simple forms of other classes of animals in the earlier geological deposits would lead us to expect also that the first forms of Mammalia would have been marsupial."

When geologists began to study the marine fossil-bearing rocks in other parts of the world, especially North America, they discovered differences in detail, as might have been expected—differences both in sediment and in fossils. In all cases, however, where the order of superposition of the layers could be clearly observed, the succession of the various groups of fossils was proved to be essentially the same as in western Europe. Rocks containing approximately the same fossils in widely separated regions may not have been contemporaneous in formation; judging by the distribution of life in the sea at the present day, they were probably not strictly contemporaneous. Always,

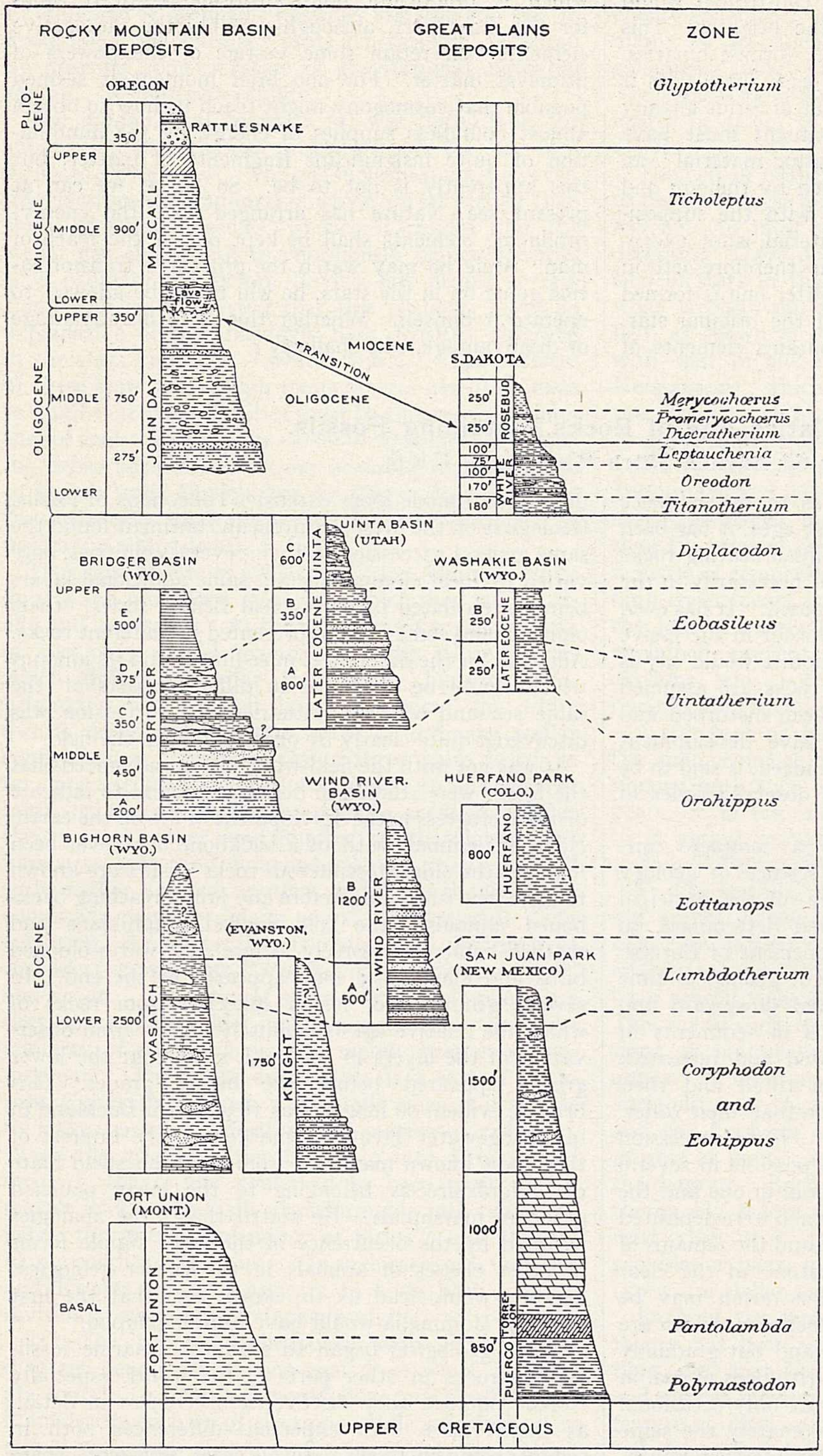

FIG. 1.—A series of sections of the Tertiary land and freshwater deposits containing fossil mammals in western North America, showing how one section can be correlated with another by noting the successive specially characteristic genera which are enumerated in the column to the right. After Henry Fairfield Osborn (*Bull. U.S. Geol. Survey*, No. 361, 1909).

however, when sections of the rocks can be studied, the various fossil-bearing deposits are found to be in the same order. The only apparent exceptions to this rule are comparatively local and in regions which show some signs of disturbance. Among the folded rocks of mountain regions, for example, the layers are sometimes overturned; while in districts where soft deposits have been squeezed by the passage of ice over them, they are sometimes broken up into patches which may be pushed together into heaps, not always in the original order.

The softness or hardness of a deposit is no criterion of its geological age, but depends merely on local circumstances. For example, on the coast of the Baltic Sea near Reval there is a soft clay which looks like a modern deposit; but it contains some of the oldest fossils characteristic of the Cambrian period, and it is shown in some places to be overlain by fossil-bearing limestones which prove that it is really of Cambrian age. Again, in Canton Glarus, Switzerland, there are hard slates of ancient aspect which are shown by their position to be of Tertiary age, and their contained fossil fishes much resemble those of which fragments occur in the Lower Tertiary clays and sands of south-eastern England. There can be no doubt that these two very different series of rocks are at least in part contemporaneous.

There must naturally be numerous gaps in the series of sea-deposited rocks in every part of a continental area, representing periods when the region was dry land or perhaps covered by water in which there was no sediment. Sometimes the elevation or depression of the land occurs without any tilting, and then, unless an old land-surface is marked by remains of vegetation (as in coal seams and in the fossil forest of the Isle of Purbeck and Portland), it can only be recognised by studying the fossils in the rocks above and below. In Morayshire, Scotland, for example, there is a thick regular series of sandstones, the lowest containing Devonian fishes, the uppermost Permian or Triassic reptiles, with no indication of the long coal period which rocks farther south prove to have intervened between the time of deposition of these two directly superposed sandstones. It is only after long and wide experience of the succession of the rocks in different parts that such "deceptive conformities" can be detected.

It must, indeed, be repeated and emphasised that the whole succession of the marine fossil-bearing rocks in western Europe—the most favourable region in the world—had been clearly ascertained before the idea of organic evolution was accepted by geologists. Fossils were appropriately termed "medals of creation" and were merely used as time-markers in cases where the superposition of the layers was obscured. In spite of earlier discussions, it was only after the publication of Darwin's epoch-making work in 1859 that the meaning of the order in which fossils were known to occur became evident. Group after group was studied from the new point of view, and the study is still in progress. The result is complete confidence in the "evolutionary stages" of all groups of organisms as guides to the relative geological age of rocks which contain them in any part of the world.

This result is important because a large proportion of the land and freshwater deposits of the latest or Tertiary epoch are comparatively limited in extent and thickness, and completely isolated on continental areas which have scarcely been affected by movements since they accumulated. These contain the remains of the ordinary land mammals from their beginning until the present day; and the mammals exhibit the most striking evidence of descent from a common ancestry of any forms of life. At first, especially in North America, it is perhaps true that confidence in the general principles of evolution led to some reasoning in a circle. When collections were made in the territories of hostile Indians there was not much opportunity for detailed field observations. In later years, however, circumstances have improved and experience has been gained, and not only in North America but also in other countries fossil mammals have been collected from beds which have been definitely observed to repose one on another.

Furthermore, there has been much certain correlation by the deposits of one isolated area, as shown by the fossils, overlapping in time the deposits of another isolated area. In illustration of this, Prof. Osborn has published the accompanying diagram (Fig. 1), which explains itself. The general evolution of the horses and camels in North America has thus been revealed, not by assuming the relative age of the beds of different areas in which their fossil remains occur, but by actual correlations made by geologists in the field. Similarly, the relative ages of the primitive ancestors of the elephants in Egypt have been ascertained by examination of perfectly clear geological sections. So many observations of this kind have now been made in various parts of the world, that palæontologists have no longer any hesitation in determining the age of an isolated Tertiary deposit by the state of evolution of the fossil mammals which it contains. They are perfectly justified in doing so, in view of the definite geological evidence which is forthcoming in so great a multitude of cases.

The evolution of life as revealed by fossils is not, therefore, a phantom arising from excess of zeal in pursuing a fascinating idea. It is as strictly the outcome of purely inductive science as any other great generalisation.

Obituary.

MR. W. P. HIERN, F.R.S.

WILLIAM PHILIP HIERN, whose death took place at the Castle, Barnstaple, on November 29, was best known for his work on systematic botany. The son of J. G. Hiern, he was born at Stafford on January 19, 1839, and entered St. John's College, Cambridge, in 1857, where he graduated B.A. as ninth wrangler in 1861, proceeded to M.A. in 1864, and was a fellow of his college from 1865 until 1868. In 1868 he incorporated as M.A. at Christ Church, Oxford, about which time he became interested in botany, and in 1873 published in the *Transactions of the Cambridge Philosophical Society* a monograph of the Ebenaceæ. He then went to the Royal Botanic Gardens, Kew, where he worked out the Meliaceæ and Sapindaceæ for Hooker's "Flora of British India," and was responsible for the greater part of volume 3 of the "Flora of Tropical Africa" in 1877, the Umbelliferæ, Araliaceæ, Rubiaceæ, Valerianaceæ and Ebenaceæ of which he worked out alone, and the Compositæ with Prof. D. Oliver.

A law suit, which had been commenced in 1873 by the King of Portugal against the executors of Dr. Friedrich Welwitsch, who had made botanical collections in Angola on behalf of the Portuguese Government, terminated in a compromise in 1875, and Hiern was appointed by the Court to separate a set and to copy the field notes on behalf of the British Museum. This he proceeded to do, and between 1896 and 1900 published in four parts a "Catalogue of the African Plants collected by Dr. Friedrich Welwitsch in 1853–1861." This completed the account of the dicotyledons, and the remainder of the catalogue was published by members of the British Museum staff. In the *Journal of Botany* for 1895, pp. 139-141, he published a note on the "Plants of Welwitsch's Apontamentos." In conjunction with C. Ficalho he worked out a collection of African plants on which a report, entitled "On Central African Plants collected by Major Serpa Pinto," was published in the *Transactions of the Linnean Society* in 1881.

Having completed his work on the Welwitsch collection, Hiern again went to Kew, where he elaborated the account of the Scrophulariaceæ of South Africa, which in 1904 occupied pp. 121-420 of volume 4, part 2, of the "Flora Capensis," after which he found himself unable to undertake further work on African botany, which was offered to him at Kew. He then retired to Barnstaple and kept the botanical records for Devon, and published in the Botanical Exchange Club Report, 1918, p. 414, a "Clavis to Devonian Sedges," based on the structure of the stems and leaves. During this period he devoted his attention to public affairs and became a Justice of the Peace and County Alderman for Devon.

Mr. Hiern was elected a fellow of the Royal Society in 1903 and of the Linnean Society in 1873; he was also a corresponding member of the Royal Academy of Lisbon. He was a widower, and his only son died some years ago.

C. H. W.

Views and News.

THE annual report of the Development Commissioners which has recently been issued is, as usual, extremely well documented. It contains *inter alia* detailed notes on the work of each of the institutions in receipt of grants for agricultural research and the closely allied " advisory " work. Full details are also furnished regarding the other than purely agricultural agencies, such as the Fishery Department, Rural Economy (as represented by the Rural Industries Bureau), and the Construction and Improvement of Harbours. The introductory portion of the report is devoted to a discussion of the question how far the expenditure by the State of a sum approaching half a million sterling annually is justified by the material progress made in the arts of husbandry. While it is true that " agriculture now requires as much aid as can be got by it from modern science," it is perhaps disappointing to observe that the Commissioners do not stress what, for want of a better epithet, may be termed the spiritual value to agriculture of education and research. If one reflects that the industry is predominatingly one which is dominated by tradition, it is surely no mean feat to have made some progress—to which the labours of the Commissioners have largely contributed—in convincing the agriculturist that the scientific method and the scientific spirit stand for progress, and that all knowledge is not crystallised in the experience of our forerunners. There is little need to deplore the " slow result being secured in the improvement of agriculture " if the Commissioners are satisfied that, with the aid of the advances made by them, new scientific discoveries —new knowledge of truth—have been achieved.

THE Commissioners are on surer ground when they say that " although the present system of agricultural education represents the growth of 35 years, it is only within the past ten or fifteen years that competent instructors [*Sc.* in the scientific principles of husbandry] have been available." It may, in fact, be counted as one of the most notable achievements of the Commissioners that they have promoted measures which by means of scholarships and otherwise have tended to recruit more competent workers to the field of the developments in which they are interested. The report closes with a statement of the finances of the Development Fund, showing that on April 1, 1924, the balance at credit was 320,000*l*. Receipts during the year amounted to 218,000*l*. Payments totalled 314,000*l*., leaving a balance at the end of the year of 224,000*l*. The payments include one of 78,000*l*. to the Irish Free State, presumably in final settlement of its " moral and material " claims against the Fund. In addition, the accounts of the Special Fund (representing the moneys secured under the Corn Production Act) show an expenditure of 152,000*l*. and a balance of 537,000*l*. The Commissioners do not say whether, as may be hoped, their balances are sacrosanct to the Chancellor of the Exchequer.

IT is announced by the Smithsonian Institution that from January 1, 1926, the Institution will furnish gratis to certain American organisations, daily or ten-day mean values of the " solar-constant " of radiation as early and as frequently as results are available from the field stations in Chile and California. In general, results are available about 24 hours after the field observations. The Institution declines, however, to furnish data of this kind regularly to individuals. From the circular in which this announcement is made, we learn that the Smithsonian Institution is concentrating attention on the measurement of radiation. The close study of the relation between radiation and weather is to cease on account of lack of funds. The yearly cost of Mr. Clayton's researches has been approximately 7500 dollars. The generosity of Mr. J. A. Roebling has permitted the Smithsonian Institution to carry them on for the past two and a half years, but that support will cease at the end of this year. Even those who are most sceptical as to the immediate value of the attempt to utilise day-to-day observations of the " solar-constant " in weather forecasting will regret that the work organised by Mr. Clayton is to lapse at the very time when his success is being proclaimed so widely by the Institution.

THE radiation observations of the Smithsonian Institution are made at observatories on mountain tops in desert regions, such sites being chosen so as to give clear dry air and freedom from cloud. The observers are exiled for long periods, to live under conditions that must be anything but pleasant, with little company and none of the recreations of the garden or the field. There is one station at Mt. Montezuma, in the Chilean Andes ; the other has just been removed from Harqua Hala, Arizona, to Table Mountain, California. The National Geographic Society has now given 55,000 dollars for the establishment of a third ; Dr. C. G. Abbot's recent visit to Great Britain was at the beginning of a tour in which he hopes to select a site in Morocco, Beluchistan, or Tanganyika. It is rightly felt that the establishment of a station in the eastern hemisphere is essential if there are rapid day-by-day fluctuations in the solar heat stream to be investigated. Even for the determination of slower variations, the elimination of atmospheric effects peculiar to different parts of the globe is necessary. It is therefore welcome news that this extension of the observing system is being made.

THE Société d'Encouragement pour l'Industrie nationale of France, in view of the important advances which have been made in the last ten years in establishing meteorology on a firm scientific foundation, and of the importance of the subject as one on which the national wealth depends, organised in May last a series of seven public lectures on its recent progress and on its applications. These lectures were delivered by some of the most distinguished of the meteorologists of France, and are reproduced in full as the July-August-September issue of the *Bulletin* of the Society. They occupy 120 pages, and are followed by a list of recent French books on the subject, with a page or two of description of the method of treatment adopted in the more important. The lectures deal with the general facts of meteorology, forecasting with special reference to the methods adopted in France and in Norway, applications in aeronautics, wireless telegraphy, navigation, agriculture, and medicine, and with the proper organisation of a national forecasting service.

The Duddell Medal of the Physical Society of London has this year been awarded to Mr. Albert Campbell, formerly of the National Physical Laboratory. The medal is awarded to those who have advanced the science of physical measurements by inventing instruments or parts of instruments of novel design. Mr. Campbell has won distinction for many new devices connected with the measurement of capacity and inductance. He was one of the first to introduce coils of small self capacity now so largely used in wireless; Campbell's system consists of a number of pancake coils separated from one another by small spaces and held rigidly together. Mr. Campbell has invented instruments for the measurement of frequency; others, known as wave sifters, for the elimination of particular frequencies; instruments, called microphone hummers, for the production of small alternating currents; and vibration galvanometers for use in measurements employing alternating current. The instrument for which he is best known is the standard mutual inductance which forms the basis of most of the accurate measurements of inductance in Great Britain. Mr. Campbell is well known for his skill as an experimenter and has made two determinations of the ohm in absolute units.

For some years the Canadian Government has been paying increasing attention to the economic potentialities of the Arctic archipelago. The dispatch of exploring expeditions and the establishment of police posts in the far north are evidence of this new interest. A special publication of the North-West Territories branch of the Department of the Interior entitled *Canada's Arctic Islands* gives an account by Mr. J. D. Craig of the work of the expedition of 1922. The scientific interests of the pamphlet lie mainly in the remarks concerning aviation in the Arctic. Major R. A. Logan, of the Canadian Air Force, who accompanied the expedition, believes that there are many places in the archipelago suitable for aerodromes, thus obviating the necessity of using hydroplanes, which are a danger because of the fragments of ice, frequently almost invisible from a height, that often occur in apparently open water. He thinks that the end of May, June, July, and part of August are almost ideal for navigation on account of weather and continuous daylight, and recommends the use of aeroplanes for survey and patrol work. Major Logan advocates the establishment of an experimental air station, with two small machines, at the police post at Pond's Inlet in northern Baffin Land. This would give valuable experience on which to base more extensive work.

A correspondent refers to the difficulty he experiences in preventing fracture of the tinted glass in the sun-cap of his telescope when used for solar observations. The heat absorption of the neutral tinted glass frequently used for this purpose is about three times that of the glasses of which the lenses are made. The tinted glass thus experiences considerable heating effect and, as it possesses no compensating advantage in regard to thermal expansion, there is consequently increased liability to fracture. When a solar prism is used, only about 5 per cent. of the heat incident on the prism is reflected into the eye-lens, and in the polarising eyepiece the heat is largely absorbed by the four reflecting surfaces. If neither of these devices is used, it is necessary to limit the amount of heat transmitted by cutting down the aperture of the object-glass to about 2 in. Precautions should also be taken to minimise the stresses set up in the tinted glass on being heated. The glass disc should not be a tight fit in the cell, nor should it be tightly screwed or bezelled in. The thinner the disc is the more readily will equalisation of temperature throughout the glass be obtained. If a thin disc does not provide sufficient absorption, it is advisable to use two such discs rather than a thick one. As a further aid towards securing equalisation of temperature, the disc should not be larger than is necessary to cover the required field. It is possible that, for solar observations, platinised glass discs might advantageously be used in place of tinted glasses. The film of platinum would act as a conducting layer and thus prevent excessive local heating. If necessary, the discs could be made of heat-resisting glass or even of quartz. These platinised glasses have the additional advantage that the absorption produced is almost uniform over the whole visible spectrum, which is not always the case with tinted glasses.

The photo-electric cell is being studied by engineers as well as by scientific men all over the world. In the newest developments of the methods of sending pictures by wires or through space by radio waves, this cell is an essential device. There are many other applications of it. In *Popular Radio* for November an apparatus is described for sorting out cigars according to colour by means of it. A beam of light is reflected from the cigar into a photo-electric cell. The alteration in the electric current actuates a relay operating mechanism which separates the cigars into three groups, light, dark, and red, according to their shade of colour. The device that has been used to measure the light coming from stars or the light needed by plants is now rapidly being applied to all kinds of commercial uses. In particular, it has recently been found most useful for measuring the intensity and quality of the light emitted from luminous sources, and much research is being carried out in this direction. The "phototron," which is a type of photo-electric cell largely used in the United States, is in appearance like an ordinary radio valve and is mounted on the standard radio valve base. It consists of a plate on which a coating of active alkali metal, generally potassium, is placed. In front of the plate there is a wire grid which serves to collect the electrons. Two of the wires connect to the grid and the third to the plate. The whole is enclosed in a glass bulb which is exhausted of air. When light strikes the plate of potassium electrons fly off. The number of these free electrons is roughly proportional to the intensity of the light. The grid being maintained at a high positive potential relative to the plate attracts the electrons to itself and they can be returned to the plate through a galvanometer. The photo-electric current through the galvanometer measures the number of the electrons. For certain purposes the photo-electric cell may serve as a "radio eye," and the human eye itself may possibly be a living photo-electric cell.

WE learn that Max Møller, of the University of Copenhagen, Denmark, has taken up the post of visiting professor of chemistry at the Chulalongkorn University, Bangkok, Siam, under the auspices of the Rockefeller Foundation of New York.

WE learn from *Science* that Dr. John J. Abel, professor of pharmacology at the Johns Hopkins Medical School, will receive the first 2500 dollars annual award of the Research Corporation of New York, as an investigator who has made " outstanding contributions to the cause of science without profit to himself."

WE understand that, having completed his work on the Atlantic eel, Dr. Johs. Schmidt, Director of the Carlsberg Laboratory, Copenhagen, is now taking up the study of the eels of the Indo-Pacific area. He is leaving in the course of a few days on an expedition to the Pacific to collect specimens and make observations, and expects to be absent for about six months.

PROF. J. W. MCBAIN, Leverhulme professor of physical chemistry in the University of Bristol, will deliver a course of lectures on colloid chemistry at the University of California, Berkeley, Cal., during the first part of 1926, and he will be the guest of honour at the National Colloid Symposium to be held in June at Cambridge, Mass.

PROF. PAUL SABATIER, professor of chemistry in the University of Toulouse, and Prof. E. L. Bouvier, professor of zoology (entomology) in the National Museum of Natural History, Paris, have been elected associates of the division of sciences of the Royal Academy of Sciences, Letters and Art of Belgium; Prof. Marc de Sélys Longchamps, of the University of Brussels, has been elected a corresponding member of the Academy.

A. SHIMOMURA has published in the Memoirs of the College of Science, Kyoto Imperial University, Series A, vol. 8, No. 6 (August 1925), an account of the low temperature carbonisation in Fischer's aluminium retort of sixteen coals of oriental origin. The samples ranged from bituminous coals, with more than 40 per cent. of volatile matter, to anthracites. From analyses of the coal and the yields of the various products, it is clear that there are some excellent fuels available in the East.

IN pursuance of the policy of carrying out a physical and chemical survey of the national coal resources of Great Britain, which is one of the main aspects of the fuel research work of the Department of Scientific and Industrial Research, a committee has been appointed to deal with the physical and chemical survey of the coalfields of Scotland. The committee includes representatives of the coal owners of Scotland, the Mining Institute of Scotland, the Scottish branch of the Geological Survey, and the Fuel Research Board. Similar committees have already been established in the Lancashire and Cheshire, South Yorkshire, and North Staffordshire areas in England.

THE issue of the latest annual report of the Technological Museum of Sydney, N.S.W., in the form of type-written sheets, indicates financial stringency, and this is also evident in the body of the report. None the less, much good work appears to be in progress, and it is particularly pleasing to find recorded a general increase in the number of applications for material for school museums. The museum has not only supplied exhibits to the schools, but has also encouraged teachers to interest their pupils in collecting local specimens and in sending them to be named and classified. This serves a double purpose: the pupils' knowledge of botany, geology, and local products is increased, while the school museums are built up by their efforts, and a keener interest created.

AN address delivered at a birth control conference in New York last March by Dr. Louis Dublin, Statistician to the Metropolitan Life Insurance Co., New York, which appears in *The World's Health*, vol. 6, No. 12, p. 505, is of some interest in connexion with the recent correspondence on the subject in NATURE. Dr. Dublin is an opponent of the broadcasting of contraceptive information without reserve, on the grounds that propaganda have been elaborated prematurely (1) without due regard to the permanent interest of the State, (2) without adequate consideration of the real population tendencies which to-day prevail, and (3) without sufficient regard to the trustworthiness and safety of the procedures recommended and to the consequences on the spiritual life of those who are influenced by the advice tendered.

THE University of Masaryk, at Brno (Brünn), issues a number of separate papers describing work carried out at the University under the general title " Publications de la Faculté des Sciences." Several botanical communications in this form have recently been received. These include systematic works, such as a revision of the genus Onobrychis (in Latin), by G. Širjaev; an account of the Compositæ collected in Turkey and Persia, by Dr. Fr. Nábělek (also in Latin); a phytogeographical study of the distribution of lichens in Moravia by Jindřich Suza (in Czech with an English summary); and two publications from the Laboratory of Plant Physiology, namely, (1) on growth reactions produced by change of *p*H on roots of *Pharbitis hispida* Choisy (in English), by Ferd. Herčík, and (2) on the growth of structures formed by boundary reactions between solutions of electrolytes in gelatin and in water, by Vladimír Morávek (in Czech with English summary).

IN the case of the Mollusca, almost more than in that of any other group of the Invertebrata, are figures necessary accompaniments to descriptions of new species, owing to the extreme difficulty of defining satisfactorily their appearance by words alone. Some societies, like the Malacological Society of London, make a practice of giving figures with all new descriptions, but that wise course is far from being so universal as it should be, while in the past it has been neglected to a lamentable degree. Conchologists, therefore, owe a great debt to the veteran Dr. W. H. Dall for his "Illustrations of unfigured Types of Shells in the Collection of the United States National Museum" (*Proc. U.S. Nat. Mus.*, 66, Art. 17), to which have been added a few figures of species elsewhere inadequately illustrated or depicted in publications difficult of access, as well as descriptions and figures of 17 new species. The work comprises 36 plates giving figures of some 200 species, and 41 pages of text confined mostly to references to the original descriptions. The figures, which were drawn as opportunity offered and put aside until publication could be made, are in different styles and reproduced by several different processes, and are all very good and clear despite the sacrifice of pleasing uniformity.

THE sixth of the booklets, 14 cm. × 11 cm., issued by the Cambridge Instrument Company, describing the firm's productions, contains 64 pages, and is devoted to instruments which have been at various times designed for special purposes. In each case a photograph of the instrument described is given, and as a rule its over-all dimensions are recorded. The first portion of the booklet is devoted to magnetographs of various types, to Galizin seismographs, and to tide recorders. Then follow spectrographs ranging from the infra-red to the ultra-violet, astronomical and sunshine recorders, X-ray track apparatus, comparators for the accurate measurement of standard tapes for geodetic surveys, deflexion and crack meters for investigating the strains in structures, permeameters for measuring the flow of gases through fabrics, sound-ranging apparatus as used in the War, and pressure recorders for use in coal-dust explosion tests. Brief notes are supplied as to the capabilities of each instrument, but more detailed descriptions are available, on request, for the use of those who require further information.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned :—A professor of biology and a professor of bio-chemistry in the College of Medicine, Singapore—Private Secretary (Appointments), Colonial Office, 38 Old Queen Street, S.W.1 (January 9). A research chemist, with knowledge of the clay industries, and research experience in connexion with clay and clay products, at the Building Research Station, Garston, Watford, of the Department of Scientific and Industrial Research—Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (January 11). Head of the Engineering Department at the L.C.C. Hackney Institute, Dalston Lane—Education Officer (T. (1) (a)), The County Hall, Westminster Bridge, S.E.1 (January 18). An assistant lecturer in Economics at University College, Southampton—Registrar.

Our Astronomical Column.

SUNSPOT DATA FROM CHINA.—Solar observations have been carried out systematically and with great zeal for many years at the Zô-Sè Observatory, China, under the direction of Father Chevalier of the Jesuit Mission at Shanghai. Vol. 14, No. 1 of the *Annals* of this observatory contains lists of sunspots and of prominences observed during the three years 1920, 1921, and 1922. The heliographic co-ordinates of the spots, date and hour of meridian passage, observed areas, and other data are carefully recorded ; and in the case of the prominences the latitudes, heights, areas, and relative brightness are tabulated. Apparently the opportunities for successful observation of prominences are limited to about sixty days annually, but these observations will nevertheless be of considerable value in co-operation with visual observations made elsewhere.

In discussing the results of the sunspot data, Father Chevalier concludes that spots do not appear at random in different regions of the sun's surface, but tend to develop in certain areas over considerable periods of time. When the observations of latitude and longitude are plotted over long periods of time, there is thus a tendency to form groups, and these sometimes tend to be drawn out obliquely with reference to the meridians, as though the foci of activity moved slowly in longitude towards east or towards west.

The remarkable interchange of activity between the northern and southern hemispheres, and the varying positions of the equatorial zone of minimum activity, are also brought out in these studies.

THE PHYSICAL NATURE OF THE SOLAR CORONA.—The *Zeitschrift für Physik* of October 20 contains the second part of a paper on the above subject by Dr. W. Anderson, with a discussion of the photoelectric and the electromagnetic theories of the corona, both of which he shows lead to great difficulties. The observations of H. Ludendorff during the solar eclipse of September 10, 1923, are referred to ; they show that the maximum of intensity in the spectrum of the corona coincides exactly with that in the spectrum of the photosphere, which is contrary to results previously obtained, and shows that the corona does not consist of incandescent particles, since the temperature of such particles would certainly be lower than that of the photosphere, and the intensity maximum would be shifted towards the red. Dr. Anderson proceeds to obtain an estimate of the effective molecular weight of the corona, based on the fact that since the pressure is small the mass absorption coefficient and the temperature radiation are small, so that alterations in state must be adiabatic. He estimates the temperature in the lower layers as 4824° Abs., which leads to a maximum value of the effective molecular weight, m, of 1/1733·5 and a minimum of 1/1906·8; in the highest regions the temperature estimate is 4236° Abs. and m lies between 1/1787·7 and 1/1985·1, with similar values for intermediate heights. According to L. Flamm, the "atomic weight" of "electron gas" is 1/1832·8, which lies between these maxima and minima.

Research Items.

SOME HINDU OBSERVANCES.—In the *Scientific Monthly* for December, Dr. Elsie Clews Parsons records autobiographical reminiscences of Somesh Chandra Bose, a Bengali of the Kshattriya caste. His family are Kulin Kasyathas and his wife was Bal, a division of the Kasyathas for whom it was an honour to intermarry with the Boses, their superiors. His own immediate family was exceptional, in that its head, an "uncle," was seventy-five years old and had not followed the usual custom of men of his age and resigned his authority to a younger brother or a son. All the names of the family had been given by this uncle instead of, as usual, suggestions having been offered by several of the family at the rice-giving ceremony. The rite of "beginning education" was performed at the age of five years by the family Brahmin, who put the pen in the child's hand and guided him in forming the letters. Although S. C. Bose was at first slow to learn, he developed a prodigious memory and an extraordinary mathematical capacity. In speaking of marriage he says that parents pay a good deal of attention to colour. They know that it is inherited, particularly if it is dark. The standards of beauty are figure, contour of face and colour. Parents may be put to a good deal of expense if a daughter is dark—an interesting commentary in practice on the colour theory of caste.

OYSTER BREEDING EXPERIMENTS.—Experiments to ascertain the conditions governing the production and settlement of oyster spat have been carried on since 1918 at the Ministry of Agriculture and Fisheries' Shellfish Research Station at Conway, and this year the Ministry's mussel purification tanks at Lympstone were also used for this purpose during the off-season for mussel cleansing. A feeding experiment with ordinary yeast carried on this year met with some success. The young oysters were able to swallow the yeast cells, and in one tank so treated at Conway a useful spatfall was secured. At Lympstone a very heavy spatfall was obtained; so many as 150 oysters settling on a tile. Two special features were noted in connexion with the tank where the heaviest spatfall occurred: first, that there was a very large population of small fish (gobies) which were absent from other tanks; and secondly, the presence of a minute vegetable organism. The intestines of the oysters were found to be full of this green material, almost to the exclusion of other organisms. The gobies may have kept the water clear of certain organisms which compete with the young oysters for food. Some hundreds have therefore been transferred to one of the tanks at Conway, and it is hoped that they may breed sufficiently to allow of experiments being carried out next year. Cultures of the special vegetable material on which the oysters were observed to feed have been made, and further experiments with this organism will also be carried on next season. Another feature was the rapid growth of the Lympstone oysters, which reached a diameter of 2 inches in less than two months: a rate of growth outside all previous experience. The spat has been laid down in the Exe Estuary, and in the Menai Straits; the mortality has been negligible. Some of the spat has also been laid down by a large firm of oyster planters at Brightlingsea.

WAXES OF INDIAN COTTONS.—A curious fact emerges as the result of a study by Leslie V. Lecomber and Maurice E. Probert of the waxes of cotton samples from different countries, by the methods which have recently been worked out in the laboratories of the British Cotton Industry Research Association (*Journal of Text. Inst.*, vol. 16, No. 11, November 1925). Whilst American and Egyptian cottons show no constant differences in the composition and properties of the wax extracted by carbon tetrachloride, which could be regarded as characterising the country of origin, in every case waxes from Indian cottons prove to be characterised by a high saponification value. This is the most outstanding character of the Indian waxes, but they also possess a relatively low melting-point, high acid and iodine values, and contain a low percentage of unsaponifiable material.

GRASS RUSTS OF SOUTH AMERICA.—J. C. Arthur reports upon the collection of grass rusts made by the late Prof. Holway during extensive journeys in South America during 1919–22, journeys made especially with the view of collecting rust fungi on grasses and on alternative host plants, in the *Proceedings of the American Philosophical Society*, Vol. 64, No. 2, 1925. This collection forms the basis for a general re-examination of all recorded data as to grass rusts in S. America, with the result that 74 species are listed with notes as to host plants and distribution; five-sixths of these species were represented in the Holway collections.

"MOULDY ROT" IN HEVEA BRASILIENSIS.—A paper by F. W. South and A. Sharples on the spread of this disease in Malaya is of interest as the record of the spread of a fungus parasite, presumably introduced about 1916 in some plantation through plant materials imported into the country, until it is now well established in a large part of the rubber-growing area (Bulletin No. 37 of Dept. of Agriculture, Straits Settlements and Federated Malay States). Inoculation experiments seem to establish definitely the identity of the causal fungus as *Sphæronema fimbriatum* (E. and H.). One spore form of this fungus, a dark-coloured endospore or macrospore, is very resistant to drying, and as the fungus is a wound parasite, it may spread by this means on the knives of the tappers as they pass from one plantation to another. The disease has now a firm hold and there seems little likelihood of its eradication, but the authors describe experiments, confirmed by extensive trials on a commercial scale, which show that it may be kept under control by painting or spraying antiseptics on to the tapping surface. Particularly good results seem to have been obtained with a proprietary article known as "Agrisol."

ZOOLOGICAL POSITION OF THE ARTHRODIRA.—The position of the Arthrodira and Coccosteomorphi among fishes has for long been debated. At one time they were thought to belong to the Dipnoi, but more modern views have brought about their removal from that group without, however, assigning them to any other definite place. Dr. Eric Stensiö of Stockholm has just published a most interesting and important paper dealing with the question in vol. 4, No. 4, of the Geological Series of the Field Museum of Natural History (Chicago, October 1925). It appears that a specimen of Macropetalichthys in the collections of the Museum gave promise of showing, after suitable development in the laboratory, something of the structure of the primitive cartilaginous neurocranium. It showed eventually much more than this, in that it has enabled Dr. Stensiö to describe in detail much of the anatomy of the brain, nerves and course of the blood vessels. These are fully described and figured in the first part of his paper. The author then describes a new genus, *Epipetalichthys wildungensis*, and in a third section gives a general review of the whole group. It comes rather as a surprise to find a list of eleven characters in the primordial neurocranium which are essentially elasmobranch, and in his concluding remarks the author, after pointing out that the Arthrodira are certainly not Crossopterygians, nor Dipnoi, nor Palæoniscids, nor *a fortiori* Actinopterygians, comes to the conclusion that as they are undoubted fishes unrelated to the non-fish Ostracodermi, then they must be elasmobranch in affinities. This view has much to commend it, but necessitates a somewhat drastic re-orientation of our ideas as to the course of evolution in the cartilaginous fishes, in that they must now be considered to have come from ancestors with a covering of true dermal bones which they have secondarily lost. The fact that bone is an exceedingly primitive substance, *e.g.* in the ostracoderms, gives some support to the thesis.

SOLUTION LAKES IN SWITZERLAND.—In a paper read on December 7 to the Royal Geographical Society on the lakes of Scotland and Switzerland, Prof. L. W. Collet directed attention to the numerous basins produced by the solvent action of water on calcareous and dolomitic strata in Switzerland. These lakes are of two kinds, according to whether they occupy a doline or a polye, the latter being the larger, and due to the union of several dolines. Lakes of this nature in the Alps frequently have their floors covered with deposits of impervious material derived from ground moraines of ancient glaciers. This points to the basins not being entirely due to chemical action. In fact, Prof. Collet believes that in the majority of cases glacial action has played a part in the process of deepening. The glacier has cleaned out and deepened a cavity formed by chemical action, and its ground moraine has completely closed up the fissures in the limestone; thus the existence of a lake has become possible. Thus the lake of Mutten, which was generally considered to be a corrie lake, proves on close examination to be a solution basin with moraine matter on its floor. The Oberstockensee and the Daubensee are cited as other examples of solution basins.

PLEISTOCENE CAVE FAUNA OF MALTA.—The annual report of the Valletta Museum for 1924–25 records many interesting additions made by Miss G. Caton Thompson to the fauna of Ghar Dalam. The bones were determined in the Geological Department of the British Museum by Miss D. M. A. Bate. The following represent genera not hitherto recorded from the cave deposits of the Maltese islands: a shrew, *Crocidura*, cf. *leucodon*; a bat, *Rhinolophus*, cf. *euryale*; a field mouse, *Apodemus sylvaticus*. The following species, recorded from these deposits for the first time, are now, except the owl, either rare visitors or entirely absent from the region: the short-eared owl, *Asio accipitrinus*; the sheldrake, *Tadorna cornuta*; the rook, *Corvus frugilegus*; and, most noteworthy, the carrion crow, *Corvus corone*. Other new records are the thrush, the blackbird, a very small fox, a small carnivore (? wolf). Considering the amount of work previously done at Ghar Dalam, this is a remarkable harvest for one season, and shows the advantage of expert co-operation. The importance of such precise details in working out the geography and climate of the period needs no emphasis.

PORCELAIN CENTRIFUGAL VESSELS IN CHEMICAL ANALYSIS.—In the *Chemiker Zeitung* of November 20 there is an interesting account by Pincussen and Arinstein of the adaptation of the centrifugal method of filtration to chemical analysis in physiological chemical analyses. The rapidity, ease, and cleanliness with which separations can be obtained render this method superior to the older methods of filtration in physiological investigations, since changes which are due to adsorption phenomena can be avoided with much greater certainty. The new vessels are made of porcelain and can therefore be ignited and weighed if necessary. Tests were made of the efficiency of the method by carrying out estimations of sulphuric acid as barium sulphate and of aluminium as alumina. In both cases the error was greater than that obtained in the usual way. On the other hand, the quantities of material weighed were unusually small.

THE ABSORPTION OF HYDROGEN BY PALLADIUM AND BY PALLADIUM SILVER ALLOYS.—The great difference between the atomic weights of palladium and hydrogen makes it impossible to determine directly the position of the hydrogen atoms with respect to those of palladium by means of X-ray spectrograms. If, however, the density of saturated palladium, which at 0° C. and 760 mm. Hg. absorbs 523 times its volume of hydrogen, or about one hydrogen to two palladium atoms, is calculated on the assumption that the hydrogen atoms replace those of palladium in the lattice, the value obtained is 7·3, while that observed is 10·76. Messrs. F. Krüger and A. Sacklowski, in a paper in the *Annalen der Physik* for November, conclude that the hydrogen atoms are distributed between the atoms of the palladium lattice, which is thus expanded considerably. They have investigated electrolytically the absorption of hydrogen and determined the dimensions of the resulting lattices for a number of alloys of palladium and silver. The result is rather remarkable; the lattice dimensions of the hydrogen-free alloys increase according to a linear law as the amount of silver increases, in accordance with Vegard's law; those of the hydrogen-saturated alloys remain practically constant from pure palladium up to about 70 per cent. silver, the amount of hydrogen absorbed following a linear law as the amount of silver is increased, and dropping to zero for about 70 per cent. of silver in the alloy.

THE PHOTOGRAPHIC ACTION OF H-RAYS FROM PARAFFIN AND ALUMINIUM.—The hydrogen nuclei ejected by collisions of α-particles have so far been mainly investigated by the scintillation method and by the Wilson cloud method. Mühlstein in 1922 indicated the possibility of the use of photography for the purpose, and in the *Zeitschrift für Physik* of October 5, Fraülein M. Blau describes a method, based on that employed by Michl in connexion with α-rays, in which the H-rays produced by the bombardment of a thin sheet of paraffin with α-rays from polonium pass at a rather steep angle through a photographic film, each H-nucleus producing a row of black dots which appear when the plate is developed. Various difficulties had to be overcome owing to the long exposure required, which made it necessary to reduce all photographic action due to β- or γ-rays to a minimum, and it was impossible to obtain results with the longer range α-particles produced by radium C, which give H-rays with a range of nearly 30 cm. and could be expected to give longer rows of black dots than the H-rays due to the α-particles of polonium, the range in air of which is only about 16 cm. A comparison experiment in which the paraffin sheet was replaced by a layer of lamp black, containing the same amount of carbon as the paraffin with very little hydrogen, did not show the rows of dots. Aluminium foil free from adsorbed gases also gave H-ray tracks in the photographic plate when bombarded with α-rays from polonium, so that it appears that the atoms of this metal can be disintegrated by α-rays of less than 4 cm. range, which agrees with the results of E. A. W. Schmidt, and contradicts those of Rutherford and Chadwick, who found a lower limit of 4·9 cm.

The Ignition-point of Gases and its Relation to Volume and Pressure.[1]

As part of the investigations on the ignition of gases undertaken by the Safety in Mines Research Board, Prof. H. B. Dixon and Mr. J. Harwood have measured the change of volume required to fire various mixtures of methane with air, and of hydrogen with oxygen, when these gas mixtures are suddenly compressed in steel cylinders.

As the compression was carried out originally, according to Prof. Nernst's suggestion, the piston was driven down by a falling weight until it was stopped by the explosion of the gases, the distance within the cylinder traversed by the piston registering the compression. Now the gases do not burst into flame at the moment the ignition-point is reached; an interval of self-heating occurs (varying in length with different gas mixtures) during which the piston will continue to descend—thus indicating a greater compression, and higher temperature, than was really needed to fire the gases. This error was corrected by stopping the piston mechanically by means of a head which was caught by steel collars of the desired thickness placed over the mouth of the cylinder. Later on another source of error was pointed out, namely, the possibility of the self-heating gases pushing up the piston and weight and thus losing heat by doing work at the beginning of the pre-flame period.

Methods have now been adopted which meet these two sources of error. The older apparatus was fitted with three powerful clamps which by means of strong springs should slide over the weight in its lowest position and hold it rigidly down on the piston. In practice it was found that the rebound of the weight when suddenly stopped prevented the certain action of the clamps: but the insertion of a small lead cylinder between the piston head and the weight allowed the weight to continue its fall (after the piston was stopped) for a fraction of a second, during which the clamps had time to make good their hold and keep the weight tight against the flattened-out lead disc.

A new machine has also been designed in which a toggle-joint (as used by Ricardo) is straightened out by a falling weight. This mechanism ensures that the motion of the piston may be stopped at any given point, and also that it may be held firmly in that position if the toggle-joint is kept horizontal. The new machine has a cylinder of twice the diameter of the old, and it is found that, while the rapidly firing mixtures such as electrolytic gas require nearly the same compressions in the two machines, the slower firing mixtures of methane and air show lower ignition-points in the larger cylinder.

To study the effect of differences in initial pressure on the ignition-point of gases—a question raised by the observation of the powerful compression-waves propagated in the firing of the high explosives used in coal-mines—Prof. Dixon, in collaboration with Mr. W. F. Higgins, has modified the concentric tube apparatus, designed some twenty years ago, so as to observe the ignition-point of various gases in air and in oxygen at pressures above and below the atmospheric pressure.

The silica cylinder surrounded by its electric furnace is encased in a strong steel vessel, and is fed from below with compressed air or oxygen—for high-pressure experiments—the excess of air escaping (with the products of combustion) at the top of the vessel. For low pressure trials the air, or oxygen, is allowed to enter below and is drawn off at the top by a motor-driven exhaust-pump, so as to maintain a constant pressure during each experiment. The combustible gas is admitted through the narrow central tube, which opens in the middle of the large cylinder, by turning a tap on the outside of the vessel—the gas passing from the holder through adjustable valves. Observation of the flame is made through a glass window, and the interval between the turning on of the gas and its ignition is timed by means of a pendulum and metronome ticking half-seconds. As the temperature rises, this interval or "lag" becomes shorter in successive experiments, and when it falls to 0·5 sec. (0·6 sec. in the case of methane) the temperature observed is called the rapid ignition-point.

The effect of variations of pressure on methane and on hydrogen was found to be very different. With methane in air, the rapid ignition-points fell regularly as the pressure was increased from 1 to 7 atmospheres, and when the pressure was lowered the ignition-points continued to *rise* so long as the gas would light, although the *rate of rise* fell off as the pressure was reduced from 150 mm. to 100 mm. of mercury. On the other hand, although the ignition-point of hydrogen in air fell regularly as the pressure was increased from 2 to 7 atmospheres, it also fell very sharply as the pressure was reduced from 150 mm. down to 75 mm. of mercury.

The experiments in oxygen confirmed these made in air, except that the rapid ignitions of methane in oxygen showed a maximum temperature at 200 mm. pressure; above or below this pressure, the ignition-point fell. This fall in the ignition-point at very low pressures appears to be a general property of gases: its cause is as yet unexplained.

[1] Substance of two papers, (1) "On the Firing of Gases by Compression," by Prof. H. B. Dixon and Mr. J. Harwood, and (2) "On the Ignition-point of Gases at Different Pressures," by Prof. H. B. Dixon and Mr. W. F. Higgins, read before the Manchester Literary and Philosophical Society on Tuesday, November 10.

British Marine Biology.

The Marine Biological Association has now at Plymouth a laboratory in the same class as those at Naples and Woods Hole. It only lacks that cosmopolitan element, which largely makes the charm at Naples. It has its zoological, physiological, and fisheries departments and a research vessel that can visit even deep-sea areas. Its growth, while largely due to the recognition of the importance of basal scientific research work in the elucidation of practical problems by the Development Commissioners, is chiefly owing to the broadness and scientific insight of its Director, Dr. E. J. Allen, this being the main factor in attracting the fifty-six naturalists who occupied its tables in the past year; Dr. Bidder has also been generous and, as treasurer, active in obtaining money for several new buildings.

The journal of the Association (vol. 13, No. 4), by arrangement, includes the work of other British marine laboratories. Prof. Meek leads off with a critical account of legislation on the catching of crabs and lobsters on the east coast of England. The crab sheds its shell in autumn and takes some months to reform and harden its new coat. It is poor in quality then, and the fishing is a most destructive one. To protect it the Eastern, North Eastern, and Northumberland fisheries committees have closed the crab fisheries at different times during these months. The author analyses the results in comparative graphs, which show quite a remarkable benefit in the total catch of each district. Northumberland gives particularly striking results, while it is shown that the Scotch coast to the north has gained by migration about a quarter of a million female crabs each year owing to this closure. The paper should be read by every legislator for, if it does nothing else, it shows by inference how foolish and wasteful it is, scientifically speaking, to have fisheries in each of our three islands in the hands of different authorities, and coastal fisheries under a series of independent local committees. Each county might just as well manage the railways within its boundaries.

F. S. Russell deals with the diurnal changes in the distribution of the macroplankton. The place sampled was about half way between the Plymouth breakwater and the Eddystone, in 51 m. of water. The date was the full moon on July 15-16, 1924, fair weather. The author clearly hopes that he was beyond the region of local swirls and upward currents, but to convince us of this he should surely have taken serial temperature and *p*H readings. We should have liked also to know a little more about the weather and particularly the strength of the light. Five series of observations at different depths were taken with a large round stramin cloth net of 2 m. diameter at approximately equal intervals. Each haul was 10 minutes. A depth recorder was attached, and the depth path of the net at each haul was recorded. The organisms caught were counted, and lists are given of those definitely migrating to the surface at night, of those dispersing evenly through the body of water, of those making smaller but yet definite upward migrations, and lastly of those not affected. The young stages of fish are omitted, but are to be recorded in a separate paper. Of isolated facts, 14,000 Tornaria-larvæ caught in the surface haul at midnight is interesting, while the various crustacean larvæ are particularly well done, thanks perhaps to the stimulus of Dr. Lebour. The work is of real importance and clearly must be repeated; we would like it to be done much farther from land and at a season when larvæ are less abundant, so that the whole problem may, to start with, be simplified as much as possible.

C. F. Hickling has been working on the Atlantic slope and there he obtained luminescence in a species of deep-sea fish, *Malacocephalus lævis*, produced by an epithelial invaginated gland opening around the anal papilla and lying in front in the ventral wall of the abdomen; it is of considerable size and is provided with connective tissue struts and a muscle sheath. The secretion is highly luminous and appears to be always poured out by the dying fish. It goes into solution in water, but constant shaking (? oxidation) is required to maintain its luminosity. It is not due to bacterial action, but to a definite substance which has been termed luciferin. It is suggested that the material may be shot out as ink is by a cuttle-fish, only here a cloud of light, while the fish darts off to escape from danger; it is also possible that the light may be used to attract food.

Four papers deal with Crustacea. Miss Jorgensen describes the early stages of Nephrops. Dr. Lebour has nearly completed the description of the stages of Nyctiphanes, while working in general on Euphausidæ, a family of considerable importance as being fed on largely by herring. Her knowledge of and insight into crustacean development is clearly an asset of importance to the Laboratory. Dr. Stephenson adds a new species of anemone to the British fauna, this being only the second new form in more than sixty years, a remarkable tribute to the zeal and insight of Gosse, whose beautiful pictures are so well known. We hope E. Mary Stephenson will continue and extend her work on the same group wherein she emphasises the fact that the cinclides may be soft spots "which can rupture neatly and without harm to the animal when needed as safety-valves." We always like to know in such work the preservatives employed, and we think important results in the minute anatomy will be attained by employing the methods of Ramon y Cajal's laboratory.

Of other papers we may refer to C. M. Yonge's account of the *p*H in the gut of Mollusca, wherein he shows that the origin of the general acidity of the entire gut lies in the style which dissolves rapidly in alkaline media, its maintenance being the result of a balance between the rate of its secretion and its dissolution; the acidity may also be caused by the salivary and digestive glands. H. W. Harvey's paper on oxidation in sea-water is mainly concerned with the actual processes, the action of a catalyst being inhibited by dissolved organic substance; the paper suggests further researches that may well lead to economic results. Finally, a new technique for studying the dissociation of oxyhæmoglobin, described by Pantin and Hogben, will make a wide appeal as it is suitable for class work. The Journal concludes with abstracts of thirteen memoirs, published elsewhere but describing the work done at the Plymouth Laboratory. J. STANLEY GARDINER.

Motor Fuels.

TO the layman the subject of motor fuel is symbolical of the entire petroleum industry, and in view of the fact that this commodity is at least a tangible and universal expression of commercial activity, there is perhaps something to be said for the idea. Listeners to the Howard Lectures at the Royal Society of Arts, delivered by Prof. J. S. S. Brame and published recently in the Society's journal, would, however, have arrived at very different conclusions concerning not only the scope of the industry, but also the complex subject of motor fuels considered as a whole, and they would have at least been impressed with one fact, namely, the rapid strides recently made in research whereby supplementary fuels to petrol are gradually being made available for general consumption.

In his first lecture the author dealt with petroleum, cracked spirit, casing-head spirit and motor benzole, and his remarks on cracked spirit were of particular interest, as this is still a much-discussed product, both from technical (*e.g.* refinement) and economic (utilisation) aspects. Efficiency of plant, loss of initial material, gas and carbon formation, and the commercial possibilities of treating residue-oil, are some of the many problems raised in this connexion, though it is clear that they are now well on the way to adequate solution. Cracked spirit is generally blended with ordinary petrol much as is the case with casing-head spirit, neither products being suitable for direct use with motor cars. Referring to benzole, the author remarked on the increasing importance of absorption processes for extracting this fuel from coal or coke-oven gas; such processes simulate those employed for recovering petrol from natural gas, *i.e.* casing-head spirit, though in the former case silica gel has apparently been successfully utilised as an absorbent.

In his second lecture, Prof. Brame discussed power alcohol, fire-risks with fuels, physical properties, boiling ranges, explosive ranges, and calorific values of various direct and mixed types. Regarding alcohol, he rightly stressed not so much the value of this compound as a fuel, but the problem of its cheap, commercial production, without which its application is impracticable. The third lecture dealt with fuel-air mixtures, composition of fuels and efficiency, current research in the United States, and the interesting subject of "anti-knock" compounds, including the famous lead tetraethyl—the distinctive but poisonous ingredient of the temporarily prohibited ethyl gasoline in America. The intricate problems of mixed fuels such as petrol-benzole, petrol-tetralin, petrol-alcohol, and alcohol-ether, etc., were touched on, the whole syllabus thus forming a most comprehensive review of the subject up to the present time.

University and Educational Intelligence.

CAMBRIDGE.—The election of Prof. J. Barcroft to the chair of physiology did not come as a surprise to those who are acquainted with the Cambridge Physiological School. He was elected a fellow of King's in 1899, in which year he won the Walsingham medal; he has held several important physiological posts and was appointed reader in 1919.

Dr. R. G. W. Norrish has been elected to a Junior Fellowship at Emmanuel College; he was recently admitted to the degree of Ph.D. for physico-chemical research.

Early in December the town was visited by numerous candidates for entrance scholarships and exhibitions. It is reported that the numbers offering physics and chemistry are considerably greater than usual, whilst those taking biological subjects have fallen off. This is an unfortunate state of affairs in view of the shortage of high-grade biological students.

EDINBURGH.—The University Court has made the following appointments in the Department of Public Health:—Colonel P. S. Lelean, until recently professor of hygiene in the Royal Army Medical College, to the Bruce and John Usher chair of public health; Dr. William Robertson, Medical Officer of Health of the City of Edinburgh, to be Director of Instruction in Sanitary Administration.

Dr. Archibald Milne, Depute Director of Studies in the Edinburgh Provincial Training College, has been appointed a lecturer in the University to conduct the course on school organisation and administration, and Mr. R. B. Kerr, a lecturer in education in the Training College, to be a lecturer in the University to conduct the course on modern educational systems and problems.

LIVERPOOL.—At a meeting of the University Council held on December 15, Associate Professor F. J. Teago was appointed to the Robert Rankin chair of electrical machinery. Dr. Teago served his apprenticeship in engineering with Messrs. Charles Parsons and Co., returning to the designs staff of this Company in 1909, after spending three years at Armstrong College, Newcastle-upon-Tyne, where he graduated with the degree of B.Sc. In 1912 he was appointed lecturer in electrical engineering at the University of Liverpool. During the War he occupied important positions in connexion with the design of electrical machinery, and as Assistant General Manager of the Ministry of Munitions Steel Works, Manchester. After the War he was appointed senior lecturer in electrical engineering at the University of Liverpool, and in 1924 the title of associate professor was conferred upon him. In 1924 he was admitted to the degree of D.Sc. (Durham). Dr. Teago has published a number of papers on electrical machinery, three of which have been awarded special premiums by the Institute of Electrical Engineers.

LONDON.—Prof. A. V. Hill has, on his appointment by the Royal Society to a Foulerton chair, resigned the Jodrell chair of physiology tenable at University College. He will carry out his research work at University College, and the Senate has resolved that he shall continue to hold the title of "Professor of Physiology in the University of London" in respect of the functions to be discharged by him at that College.

The following doctorates have been conferred:—*D.Sc.* (*Embryology*), Mr. A. S. Rau (University College) for a thesis entitled "Contributions to our Knowledge of the Structure of the Placenta of Mustelidæ, Ursidæ and Sciuridæ"; *D.Sc.* (*Physics*), Mr. W. B. Haines (University College and the Rothamsted Experimental Station) for a thesis entitled "Studies in the Physical Properties of Soils"; *D.Sc.* (*Metallurgy*), Miss Constance F. Elam (Imperial College—Royal School of Mines) for a thesis entitled "(1) Tensile Tests of Crystals of an Aluminium-Zinc Alloy; (2) The Orientations of Crystals in Metal Test-pieces subjected to small Strains followed by Heat-treatment."

THE University College of the South-West of England, formerly known as University College, Exeter, directs attention in its report for 1924–25 to the harmonious development (justifying its change of name) of its scheme for co-operation with the Technical School, Plymouth. With effect from the beginning of the current session, the more technical part of the School of Pharmacy has been transferred to Plymouth, while the pure science part of the curriculum continues to be provided at Exeter as well as at Plymouth. The Department of Law also provides courses at Plymouth, and a project is on foot for establishing a School of Commerce there. The total number of full-time students has increased from 313 to 332, the increase of science degree students alone being from 67 to 87, and of pharmacy diploma students from 10 to 18. The number of degree students has more than doubled in the last four years.

STATISTICS of State Universities and State Colleges for the year 1923–24 are published in Bulletin, 1925, No. 12 of the United States Bureau of Education. Similar annual returns have been published by the Bureau for the past sixteen years, but in this bulletin appears for the first time a tabular statement of tuition and other fixed annual charges payable by students. The subject is one to which much attention has been directed of late. In the institutions, 106 in number, represented in the returns, the total student enrolment, excluding the summer school, was men 148,230, and women 77,567; and the student fees paid, excluding board and room rent, amounted to sixteen million dollars. There is very great diversity of practice in regard to the fixed charges which students are called upon to pay in these state universities and colleges, the amounts varying, in arts and sciences, for tuition and other fixed annual charges, excluding laboratory fees, from nine dollars in the University of Oklahoma to 314 dollars in Cornell University. The table includes figures for medicine, dentistry, law, and pharmacy as well as arts and sciences; in almost all instances the rates for other courses of study such as engineering and agriculture are the same as for arts and sciences. The highest professional school tuition charges are 500 dollars per annum for the Medical School of the University of California. Many institutions at which tuition is nominally free impose "incidental" and "registration" charges, generally small but sometimes considerable, *e.g.* Pennsylvania State College, 100 dollars.

Contemporary Birthdays.

January 1, 1855. Sir Charles L. Morgan, Past Pres. Inst.C.E.

January 5, 1846. Sir John Arrow Kempe, K.C.B.

January 8, 1845. Rt. Hon. Sir Herbert E. Maxwell, Bart., F.R.S.

January 8, 1856. M. le Prof. Henri Lecomte, Natural History Museum, Paris.

January 8, 1868. Sir Frank W. Dyson, F.R.S.

Born at Edinburgh, Sir HERBERT MAXWELL was educated at Eton and Christ Church, Oxford. As naturalist, antiquary, and worker in the public service, Sir Herbert's many-sided activities have had ample play on both sides of the Border. An ardent chronicler of Scottish history, he was president of the Society of Antiquaries of Scotland, 1900-13, and a lecturer in the University of Glasgow during that period. A recognised authority on Scottish historical monuments, he was Rhind lecturer in archæology, University of Edinburgh, 1893-1911. Sir Herbert was chairman of the Royal Commission on Tuberculosis, 1897-98, afterwards representative of H.M. Government at the Berlin Congress on the Prevention of Tuberculosis. Many papers in the issues of the Scottish Natural History Society on the habits of animals and birds proceed from his facile pen. Fisherman and botanist, he has published "Salmon and Sea-trout" (1899), "Fishing at Home and Abroad" (1914), "Trees, a Woodland Notebook" (1914), "Flowers, a Garden Notebook" (1923). His "Memories of the Months" (1897) has gone through many editions. In August last Sir Herbert was appointed by the Crown chairman of the board of trustees of the newly constituted National Library of Scotland, arising from the transfer of the great library of the Faculty of Advocates as a nucleus.

Prof. LECOMTE, an Officer of the Legion of Honour, is one of the two professors of botany in the Natural History Museum, Paris. He was elected a foreign member of the Linnean Society in 1916, the following year becoming a member of the Paris Academy of Sciences. Professor at the Lycée St. Louis, 1884-1903, he joined the museum staff in 1906. Founder and first editor of the *Revue des cultures coloniales* (1897), Prof. Lecomte is author of various important works, notably, "Les Textiles végétaux et leur examen micro-chimique" (1892), and "Le Coton en Égypte" (1904).

Sir FRANK DYSON, born at Ashby, was educated at Bradford Grammar School, proceeding thence to Trinity College, Cambridge, graduating second wrangler. He was also Smith's prizeman. Chief Assistant at the Royal Observatory, Greenwich, 1894-1905, he was next appointed Astronomer-Royal, Scotland, returning to Greenwich in 1910 to take up the post of Astronomer-Royal. Sir Frank was awarded a Royal medal by the Royal Society in 1921. It was recorded that among many important contributions to astronomy he had devoted special attention to investigations of the movements and distances of the stars, and of the bearing of these upon the structure of the stellar universe. He had been conspicuously successful in obtaining records of the spectrum of the corona and chromosphere during eclipses of the sun. Sir Frank is a corresponding member of the Academy of Sciences, Paris, and a foreign member of the Reale Accademia Nazionale dei Lincei, Rome.

Societies and Academies.

LONDON.

Royal Meteorological Society, November 16.—I. D. **Margary**: The Marsham phenological record in Norfolk, 1736–1925, and some others. A remarkable phenological record kept by five generations of one family at Hevingham near Norwich is presented. The observations include the dates of leafing of 13 common trees, flowering of snowdrop, hawthorn, etc., and the movements of 8 migrant and other birds. The mean date for a group of seven of the plant events covering the period January-May has been worked out for each year. The annual variations are closely related to temperature and show a very definite periodicity, averaging twelve years between unusually backward springs or early springs. Recent extreme years are: early, 1912, 1921; late, 1908, 1917. The intervals have recently been shorter than the average. Comparing the plant dates in the eighteenth and twentieth centuries (taking averages for the thirty-five year periods 1751–85 and 1891–1925) of the 16 plants, 10 were earlier in the recent period, 3 were unchanged, and 3 later, possibly an indication of an earlier tendency in recent springs. Migrant birds seem independent of these conditions. The swallow's date of arrival is definitely getting later (the average for the thirty-five years 1891–1925 being eight days later than for 1751–85), in contrast to that of the cuckoo, which has on the average kept a constant date throughout the period.—C. D. **Stewart**: Experiments in the shielding of rain gauges. The chief difficulty met with in the measurement of rainfall is the effect of wind in decreasing the catch of a gauge owing to the eddies set up by its projecting parts. At Valencia Observatory it has been found that protection is afforded in varying degrees by buildings, the Nipher shield and pits.—Harold **Jeffreys**: On the dynamics of geostrophic winds. All problems of the motions of the atmosphere produced by temperature changes of large horizontal extent can be reduced to closely related problems of tides in an ocean of uniform depth, and, in the absence of friction, they can in general be solved by known methods. The theory is applied to the annual variation of pressure in Central Asia, and gives fair quantitative agreement. When applied to the general circulation, however, it gives easterly winds everywhere. Friction would considerably alter this result; indeed a steady circulation is impossible when friction is present. The only dynamically admissible types of motion with friction involve westerly circulations around the poles and systems of cyclones the height of which is comparable with that of the tropopause.

Geological Society, December 2.—R. D. **Oldham**: The depth of origin of earthquakes. Methods of determining the depth of origin of an earthquake, dependent on observations of the time of occurrence, demand records of a degree of precision, and in numbers, which are seldom available. The same objection applies to the Dutton method, based on variation in the intensity of shock; but the method is capable of a simplification which will make it applicable to any case where the area affected by the sensible shock, and the maximum degree of violence attained, can be determined. The Dutton method is sound in principle, but two important errors have been introduced in the application. Acceleration has been taken as the measure of intensity, whereas the formula demands that the product of maximum acceleration and amplitude of displacement should be used; and the effect of absorption of energy in transmission has been treated as negligible. The errors so introduced are, however, opposite in sign and about equal in amount, so the depth obtained is approximately correct. The simplified method is applied to the discussion of the Italian record for the years 1897–1910, comprising 5605 distinct shocks: it is found that more than 90 per cent. of these originated at depths of less than 10 km., and mostly round about 5 km.; while only 1 per cent. originated at depths exceeding 30 km. This is in strong contrast with the depths of origin of the distant records, which seem to vary from 50 km., in a few cases, to, in most cases, 100 km. or more. From this it is concluded that where distant records accompany a destructive earthquake, the disturbance has a two-fold origin, the episeism, or surface-shock, by which the damage is directly caused, being a secondary result of the bathyseism, which is the origin of the distant record. The great number of local shocks are purely episeisms, without any recognisable bathyseism.

Linnean Society, December 17.—H. Graham **Cannon**: On the feeding mechanism of a freshwater ostracod, *Pionocypris vidua* (O. F. Müll.). The shell-cavity is incompletely divided into an anterior and a posterior chamber by the large "oral mass" suspended from the more dorsal parts of the valves. The mouth-entrance is on a level with the ventral edges of the shell. A stream of water is caused to pass antero-posteriorly through the shell by three vibratory plates. The organism is essentially a crawling form, and feeds on anything that it kicks up in its wanderings. The disturbed particles are sucked in by the water stream and eventually are transferred to the œsophagus by a pair of "food rakes" that occur in the posterior wall of the oral cavity.—R. R. **Gates**: The vegetation of the Amazon basin. The whole of the Lower and Middle Amazon basin, from the Atlantic to the Andes, lies within a few degrees of the equator and represents the greatest area of forest in the world. Practically the whole region is clothed with luxuriant tropical rain-forest. The Amazon surpasses any other river in its drainage-area and in the volume of water discharged, the main channel being 40 to 60 fathoms deep up to Manaos (1000 miles). At high river, in June, the water-level is in many places more than 50 feet above its level at the end of the "dry" season. As the river rises, thousands of square miles of forest-country are inundated. This is known as *igapo*, and the annual flooding has striking effects on the vegetation. Among floating plants, several species of Eichhornia are common; and *Victoria regia* spreads its leaves in sheltered lagoons. Another characteristic plant along the river is a gigantic "pampas" grass (*Gynerium sagittatum*), called *flexa* in Portuguese, because the upper part of the stalk is used to make arrows for shooting turtles. Small fine-leaved bamboos of many species occur in some places. The two most numerous families in the forest are the Cæsalpinioideæ and the palms.

CAMBRIDGE.

Philosophical Society, December 7.—R. W. **Ditchburn**: The quenching of resonance radiation and the breadths of spectral lines. The virtual radiation theory put forward by Slater and others is incompatible with one or other of the sets of experimental results by Stuart, Fuchtbauer, Joos, and Dinkelacker.—G. H. **Briggs**: A photographic method of determining the mobility of recoil atoms. The method is a modification of Zeleny's, using parallel plates. The source of recoil atoms was a narrow line of mesothorium bromide on platinum on the lower plate perpendicular to the direction of the air stream. Such a source gives thorium X, thorium A, and thorium B by recoil. These atoms are carried across by the electric field to the top plate and give two bands of activity, one when there is no air current and a displaced band when there is a steady flow of air between the plates. The distribution of activity on the top plate was found by exposing it directly to a photographic plate and measuring the bands obtained with a microphotometer. No detectable difference in the mobilities of thorium X, A, and B was found, but there appeared to be a continuous distribution of mobilities from 1·24 to 1·84 with a maximum at 1·56 cm. per sec.—R. L. **Alston**: (1) Some developments in the X-ray analysis of single crystals. Müller's method of single-crystal analysis has been extended to iron crystals, for which [110] axes only are conveniently determined. For a given angle of reflexion, the axes determined by this method at a given point on the surface must lie within a limited region, if neither the incident nor the reflected beam is to be obstructed by the body of the crystal. For a plane surface the limits of this region have been calculated and plotted in diagrams for several reflexion angles. A method of analysis making use of reflexions from the continuous spectrum has also been developed. (2) The distortion of large aluminium crystals at crystal boundaries. In a test-piece composed of several large aluminium crystals, the distortion under a tensile load is less near the crystal boundaries than in the body of the crystal. X-ray analyses show that the distortion becomes progressively less as the boundary is approached, from a distance of two or three mm., but is of the same character as that in the body of the crystal, *i.e.* a shear on the same plane and in the same direction. The boundaries are more rigid than the crystals and one crystal does not slide over another.—P. A. M. **Dirac**: The adiabatic hypothesis for magnetic fields. A dynamical system undergoing an adiabatic change does not necessarily satisfy Hamilton's equations when it involves forces depending on the velocities. For a system in an adiabatically varying magnetic field, the electric forces which necessarily accompany the varying magnetic field just compensate for the preceding effect; thus the usual proof of the adiabatic invariance of the quantum integrals, based on the assumption of Hamilton's equations, is valid.—E. L. **Ince**: (1) Periodic solutions of a linear differential equation of the second order with periodic coefficients. (2) The second solution of the Mathieu equation.—G. **Timms**: The equianharmonic and harmonic envelopes of a quadrinodal cubic surface.—M. J. M. **Hill**: On the substitution of Wallis's postulate of similarity for Euclid's postulate of parallels. Addendum.—C. G. F. **James**: On a family of constructs in higher space.

EDINBURGH.

Royal Society, December 7.—W. J. M. **Menzies**: Salmon (*Salmo salar*) of the River Moisie (E. Canada). These salmon are very similar in their habits of life to salmon in Great Britain, and their scales are a good indication of their age and history. The average age of the smolts at migration is rather higher than the average age of the salmon in the northern rivers of Scotland, though they are not quite so old as the smolts in many of the Norwegian rivers. The percentage of fish which have spawned on one or more occasions is also higher than in Britain, and one salmon was found which had spawned no less than four times. The majority of fish belong to the large spring or three winters in sea class and their average weight is therefore considerable.—Fred. J. **Symon**: The diffusion of salt vapours in a bunsen flame. It has been previously shown by Prof. H. A. Wilson that for a bead of salt evaporating in a bunsen flame the coefficient of diffusion of the metallic vapour in the flame may be determined if the positions of two points are known where the concentration of the vapour is the same. Points of equal concentration can be found by an electrical method and the values obtained for the coefficient agree with the values previously got by H. A. Wilson.—William Cooper: Note on copper tinted flame caps: an investigation into the colorations obtained in examining different inflammable gas mixtures, using a copper loop in the testing flame, and carbon tetrachloride in the fuel.—F. A. E. Crew: Prenatal death in the pig and its effect upon the sex-ratio. The secondary sex-ratio in the pig is equality; the primary, as revealed by an examination of fœtuses, is not less than 150 male : 100 female. The very considerable prenatal mortality bears more severely upon the male throughout the pregnancy.—E. L. Ince: Researches into the characteristic numbers of the Mathieu equation. This paper is a first step towards the efficient tabulation of the Mathieu functions. The author gives a method by which the characteristic numbers may be evaluated for reasonable values of the parameter q. A table of the five lowest characteristic numbers is given from $q=0$ to $q=1$.—T. M. MacRobert: The addition theorem for the Legendre function of the second kind. The addition theorem for the function $Q_n(z)$, which was established by K. Neumann for positive integral values of the degree n, is proved to be still valid when n is not an integer.—Sir Thomas Muir: The theory of continuants from 1900 to 1920.

PARIS.

Academy of Sciences, November 30.—L. Lecornu: The problem of refraction.—L. E. Dickson: New algebra of division.—H. Kamerlingh Onnes, Jean Becquerel, and W. J. de Haas: The magnetic rotatory power of some paramagnetic minerals at very low temperatures. The magnetic rotatory power of tysonite has been measured at temperatures ranging down to the boiling-point of liquid helium. From the figures obtained it would appear that the susceptibility of tysonite follows Curie's law, with a small correction. Parisite and bastnæsite have also a considerable magnetic rotatory power, although less than that of tysonite. The variations with temperature follow an analogous law.—C. Sauvageau: The localisation of bromine in an alga (*Antithamnionella sarniensis*). The author has recently demonstrated the presence of free iodine in two algæ, especially in certain organs to which the name of *ioduques* has been given. Similar cells have now been found in *A. sarniensis*, for which the name of *bromuque* is suggested, since they appear to contain bromine instead of iodine. As the reagent for bromine, a solution of fluorescene is used; this is converted into eosin by the substance present in the cells. The bromine must either be free, or present in a very loose combination.—E. F. Collingwood: A theorem of Lindelöf.—J. Sudria: The determination of the projected displacement of a point of a body at the centre filament.—Const. Parvulesco: The conditions of equilibrium of a stellar cloud isolated and deprived of rotation.—G. van Lerberghe: The specific affinity as a function of the fugacities.—Marcel Peschard: Some relations between artificial ferro-nickels and a nickel iron of meteoric origin. A study of the Chinautla meteorite (1902). The measurements showed that the meteorite was in physico-chemical equilibrium whilst the artificial ferro-nickel was in a metastable state.—Mme. J. S. Lattès and Georges Fournier: The absorption of the β-rays by matter. It has been shown that for the primary β-rays from radium E, the coefficient of absorption is a linear function of the atomic number. It is now shown that the absorption of the secondary β-rays produced by the primary γ-rays of radium rigorously follows the same law.—Jean Thibaud: The structure of the nucleus of the radioactive atoms and the emission of spectra of the γ-rays.—C. Matignon and Mlle. G. Marchal: The thermochemistry of glucinum.—Louis Jacques Simon: Viscosity and chemical analogy with respect to the viscosity of the metallic acetates in aqueous solution.—Paul Hænni: Boron in aluminium and aluminium alloys. A study of the changes in the mechanical properties of aluminium and some aluminium alloys produced by the addition of varying proportions of boron.—Raymond Charonnat: The complex combinations of the ruthenium chlorides.—R. Mellet and M. A. Bischoff: The application of the phenomena of dyeing to the revivification of printed or written matter removed by chemical treatment. In the case of an altered cheque, in which the original writing had been removed by chemical reagents, immersion in solutions of fluorescent substances (such as eosin), and subsequent examination by filtered ultra-violet light, brought out the original writing.—R. Gaubert: The identity of fibrous limonite with göthite. The facts described prove that fibrous limonites are merely impure göthite.—P. Russo: Tectonic and palæontological notes on the region of Bab Moroudj.—Émile Belot: The dynamical and isostatic causes of the dissymmetries of the hemispheres of the earth and moon.—P. Lejay: Storm perturbations of the electric field and their propagation to great distances.—G. Delépine: The Goniatite zones of the upper Dinantian and of the Chokier layer in Belgium.—Louis Emberger: The reversion of the plasts in plants. The most important phenomenon in the reversion of the plasts is the subdivision of the substratum, comparable with a sort of pulverisation of the mitochondrial substance, after the resorption of the products of elaboration (starch, pigments). The plasts, after reversion, keep their biological individuality even when they are entirely in the state of mitochondria.—Jacques Pellegrin: The reptiles and batrachians of the Grand and Middle Atlas.—L. Mercier and J. Villeneuve: Contribution to the study of the anatomy of the head of the Diptera (*Calliphora erythrocephala*). The ptilin and ptilino-pharyngeal muscle.—J. Giaja and X. Chahovitch: The maximum metabolism and the suprarenal capsules. From experiments involving partial and total ablation of the suprarenal capsules of the rat, it would appear that these capsules play an important part, perhaps even the essential part, in the accommodation of thermo-genesis.—Max and Michel Polonovski: A series of alkaloid derivatives with attenuated toxic power. In an earlier communication it has been shown that geneserine from the Calabar bean, in which the basic tertiary nitrogen of eserine is blocked by oxygen, while possessing the physiological and therapeutic properties of eserine, is only slightly poisonous. An attempt has now been made to see if blocking the nitrogen atom with oxygen produces the same effect in other alkaloids, these compounds being named by analogy genatropine, genostrychnine, etc. It has been found that in the case of the nitrogen-oxides of atropine, hyoscyamine, scopolamine, and strychnine, the specific physiological action of the original alkaloid is preserved but that the toxic action is greatly reduced.—C. Gessard, E. Fernbach, and G. Rullier: Morphological modifications of the tubercle bacillus in a culture associated with a pyocyanic bacillus (melanogen variety).— — Cluzet and — Chevalier: Unidirectional high frequency current; physiological effects. By interposing an electronic valve in the circuit of a medical high frequency installation, a unidirectional current of the same frequency is obtained. A description of the physiological effects produced by these rectified high frequency currents is given.

SYDNEY.

Linnean Society of New South Wales, October 28.—W. W. Froggatt: Notes on Australian Coccidæ with descriptions of new species. Descriptions of three species of Lecanium as new. They were found in cavities in branches or trunks of forest trees. As the inner surfaces of these cavities are hard, dry, and sapless, the larvæ apparently develop into adult females with very little moisture or apparent food.—May M. Williams: The anatomy of *Lindsaya linearis* and *L. microphylla*. The apices of the rhizome, leaf, and root of both forms are of the normal leptosporangiate type. The petiolar bundle forms a single strand containing three protoxylem groups, two of which are endarch in position; the third (median) group in *Lindsaya linearis* is exarch, but in *Lindsaya microphylla* occupies various positions at different levels of the petiole, these positions varying from exarch to endarch.—A. M. Lea: Descriptions of new species of Australian Coleoptera. Pt. xviii.—W. F. Blakely: Contributions to our knowledge of the flora of New South Wales. Four new species, one each of the genera Grevillea, Tetratheca, Astrotricha, and Olearia.—R. J. Tillyard: Two new species of silky lacewings (Fam. Psychopsidæ, Order Neuroptera Planipennia) from Australia. These bring the total of species described from Australia to twelve. One is from central Queensland and is nearest to *Psychopsis gracilis*, the other is from Roebourne, W.A.—P. D. F. Murray: A note on an unusual type of secreting epithelium in the Wolffian duct of the dog-fish (*Scylliorhinus canicula*). The epithelium is one or two cells thick, the cells being of low columnar form, and was noticed both in the vas deferens and in the vesiculum seminalis.

Diary of Societies.

SATURDAY, JANUARY 2.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir William Bragg: Old Trades and New Knowledge: (3) The Trade of the Weaver.

MONDAY, JANUARY 4.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 3.30.—Mrs. Julia Henshaw: The Mountain Peaks of Canada (Christmas Lecture to Young People).

CHILD-STUDY SOCIETY (at University College), at 5.—W. S. Rowntree: The Childhood of the Race.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.—Sir C. Nicholson and Sir Francis Fox: Lincoln Cathedral.

ARISTOTELIAN SOCIETY (at University of London Club), at 8.—C. A. Richardson: Paper.

TUESDAY, JANUARY 5.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir William Bragg: Old Trades and New Knowledge: (4) The Trade of the Dyer.

OPTICAL SOCIETY AND PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology), Afternoon and Evening.—Exhibition of Electrical, Optical, and other Physical Apparatus.

INSTITUTION OF AUTOMOBILE ENGINEERS (at Royal Society of Arts), at 7.

INSTITUTION OF ELECTRICAL ENGINEERS (North-Western Centre) (at Engineers' Club, 17 Albert Square, Manchester), at 7.

INSTITUTE OF METALS (Birmingham Section) (at Chamber of Commerce, Birmingham), at 7.—O. F. Hudson: The Influence of Work and Annealing on Brass.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—F. C. Tilney: Form and Content in Pictorial Art.

HULL CHEMICAL AND ENGINEERING SOCIETY (at Grey Street, Hull), at 7.45.—A. Grounds: Fuel Economy in Steam Plants.

RÖNTGEN SOCIETY (at British Institute of Radiology), at 8.15.—Dr. G. W. C. Kaye: (*a*) A Combined X-ray Tube and Vacuum Pump Unit; (*b*) The Industrial Uses of X-rays—The Present Position.—A. F. Dufton: The Measurement of Radium during Radioactive Growth.

SCIENCE MASTERS' ASSOCIATION (Annual Meeting) (at Household and Social Science Department, King's College for Women), at 8.15.—The Bishop of Birmingham: Presidential Address.

WEDNESDAY, JANUARY 6.

SCIENCE MASTERS' ASSOCIATION (Annual Meeting) (at Household and Social Science Department, King's College for Women), at 10.45 A.M.—Dr. T. Slater Price: The Sensitivity of the Photographic Plate (Lecture).—Prof. Leonard Hill: Sunshine, Open Air, and Health (Lecture).—At 12.—W. D. Eggar, O. H. Latter, and others: Discussion on Science and Citizenship.—A. M. Weaver, E. H. Duckworth, and others: Discussion on Laboratory Assistants and Laboratory Management. School Exhibitions.—At 5.15 and 6.—Prof. B. J. Collingwood: Demonstration of the Use of Specially Designed Electronic Models for the Representation of Chemical Actions and Electrolytic Phenomena.—At 8.15.—(Lecture-demonstration.) Arranged by Dr. C. S. Myers and F. M. Earle: Methods of Experimental Psychology.—(Demonstrations of Vocation Tests.) Miss W. Spielman: Vocational Selection.—Vocational Guidance:—Miss Stott: Intelligence Tests; Miss Roberts: Manual Ability Tests; A. Macrae: Mechanical Tests; F. M. Earle and Miss Blackett: Special Tests, Job Analysis and Rating Scales.

OPTICAL SOCIETY AND PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology), Afternoon and Evening.—Exhibition of Electrical, Optical, and other Physical Apparatus.

ROYAL SOCIETY OF ARTS, at 3.—Prof. H. E. Armstrong: Alice in Wonderland, at the Breakfast Table (Mann Juvenile Lectures) (1).

GEOLOGICAL SOCIETY OF LONDON, at 5.30.—W. N. Edwards: Fossil Plants from the Nubian Sandstone of Eastern Darfur.—V. G. Glenday and Dr. J. Parkinson: The Geology of the Suk Hills (Kenya Colony).

INSTITUTION OF ELECTRICAL ENGINEERS (Wireless Section), at 6.—Lt.-Col. K. E. Edgeworth: Frequency Variations in Thermionic Generators.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS (at Caxton Hall, Westminster), at 7.—J. R. Preston: Pump Circulation.

THURSDAY, JANUARY 7.

GEOGRAPHICAL ASSOCIATION (Annual Meetings) (at London School of Economics), at 9.50 A.M.—Opening of Publishers' Exhibition and Short Address.—At 11.15.—The Hon. W. G. A. Ormsby Gore: The Economic Geography of the British Empire (Presidential Address).—At 5.—Prof. J. L. Myres: Wayside Geography (Lecture).—At 8.—Private Meeting of University Teachers of Geography. Mrs. Ormsby and others: Discussion on The Compatibility of the Training of the Geographer with the Acquisition of a University Degree in Geography.

SCIENCE MASTERS' ASSOCIATION (Annual Meeting) (at Household and Social Science Department, King's College for Women), at 11 A.M.—D. J. Berridge, E. Nightingale, E. G. Laws, and others: General Discussion: School Science Examinations.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Old Trades and New Knowledge: (5) The Trade of the Potter.

OPTICAL SOCIETY AND PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology).—Afternoon and Evening.—Exhibition of Electrical, Optical, and other Physical Apparatus.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—Capt. P. P. Eckersley: Past, Present, and Future Developments in Wireless Telephony.

SOCIETY OF CHEMICAL INDUSTRY (Manchester Section) (at 16 St. Mary's Parsonage), at 7.—Short Papers.

SOCIETY OF CHEMICAL INDUSTRY (Bristol Section) (at Bristol University), at 7.30.—S. Robson: The Contact Process for Sulphuric Acid.

INSTITUTE OF METALS (London Section) (at 85 The Minories), at 7.30.—H. J. Gough and D. Hanson: The Fatigue of Metals: a General Survey and an Account of some Recent Work. Pt. I.

INSTITUTION OF SANITARY ENGINEERS (at Caxton Hall), at 7.30.—Presidential Address.

INSTITUTION OF STRUCTURAL ENGINEERS, at 7.30.—J. T. Jacques: The Manufacture and Strength of Brickwork.

FRIDAY, JANUARY 8.

GEOGRAPHICAL ASSOCIATION (Annual Meetings) (at London School of Economics), at 9.30 A.M.—Exhibition.—At 10 A.M.—A. G. Ogilvie: South America and Africa as Fields for Geographical Research (Lecture).—At 11.15.—Sir John Russell: Cotton and the Nile (Lecture).—At 2.15.—Sir Halford Mackinder: The Teaching of Geography (Lecture).—At 3.30.—Dr. Vaughan Cornish: The Rhythmic Flow of a River (Lecture).

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 3.30.—A. F. R. Wollaston: A Naturalist's Journey to Ruwenzori (Christmas Lecture to Young People).

ROYAL ASTRONOMICAL SOCIETY, at 5.—*Paper received*:—J. G. Hagen: W. Herschel, Discoverer of Dark Cosmic Clouds.

MALACOLOGICAL SOCIETY OF LONDON (at Linnean Society), at 6.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—Third Report of the Marine Oil-Engine Trials Committee.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—Mrs. J. Henshaw: Camping in the Canadian Rockies (Lecture).

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—A. J. Simpson: Notes on Salesmanship.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Newcastle-upon-Tyne), at 7.30.—W. Pollock: Star Contra Propeller.

GEOLOGISTS' ASSOCIATION (at University College), at 7.30.

ROYAL TECHNICAL COLLEGE, GLASGOW, CIVIL ENGINEERING SOCIETY, at 7.30.—G. Fairbairn: Some Applications of Cementation to Engineering Works.—J. W. Mearns: Experiences in British Guiana.

SOCIETY OF CHEMICAL INDUSTRY (Chemical Engineering Group) (at Chemical Society), at 8.—A. E. Knowles: The Manufacture of Hydrogen suitable for the Hydrogenation of Oils.—Dr. A. C. Thaysen: The Production of Hydrogen by Micro-organisms.

ROYAL SOCIETY OF MEDICINE (Ophthalmology and Laryngology Sections), at 8.30.—Discussion on Inflammation of the Nasal Sinuses in its Relation to Optic Neuritis.

SATURDAY, JANUARY 9.

GEOGRAPHICAL ASSOCIATION (Annual Meetings) (at London School of Economics), at 9.30 A.M.—Exhibition.—At 10.—Prof. P. M. Roxby: The Concept of Natural Regions in the Teaching of Geography, with Special Illustrations from China.—At 11.15.—Discussions held concurrently in separate rooms:—C. G. Beasley and others: The Place of Geology in a Two Period a Week Geography Course.—C. D. Forde and others: Detail in Geography Lessons.—Major A. G. Church and others: Geography in Relation to other School Subjects.—Miss R. M. Fleming and others: Geography for the Younger Children in Primary Schools.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir William Bragg: Old Trades and New Knowledge: (6) The Trade of the Miner.