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The Study of British Archæology.

ARCHÆOLOGICAL studies, like many other things, have changed greatly since the War. They have now passed definitely and finally from the province of the antiquarian and the dilettante. In Great Britain, science, at least in certain of its branches, has always been the playground of the amateur; and archæology perhaps more than any other of these studies, except perhaps astronomy, owes much to his efforts. But long before the War it had been made evident that archæological exploration demanded more than merely the opportunity and the means—for digging is an expensive business—to open up a burial mound or a prehistoric settlement. It needs but a glance through the pages of an archæological publication with a long run, such as *Archæologia*, for the last thirty or forty years, to appreciate the vast amount of excellent work that has been done in Great Britain on thoroughly sound lines by men who were scientific in method if in status they were amateur.

Excellent as this work was, too often its outlook was restricted and its interest confined to one aspect or to one type of problem. To-day, it may seem scarcely credible that in the last decade of the nineteenth century the British Association appointed a committee to ensure the record and preservation of objects not of Roman or Romano-British origin found in the excavation of Romano-British sites in Britain. In spite of the interest that has been taken in Roman antiquities in Britain—an interest which has been alive literally for centuries—we still know little of the relation of British settlement and Roman site—less indeed than of almost any other question in British archæology; and it is only now that investigations at St. Albans, Colchester, Llanmelin, and one or two other sites are gradually accumulating the needed evidence. In some phases of prehistoric archæology the available material along certain lines is plentiful; along others, certainly of no less importance, it may be scanty, or even entirely lacking.

It is not without significance that archæologists are now prone to speak of 'prehistory', perhaps even more than they use the term 'prehistoric archæology'. The change may be one of orientation only; but it is a change which carries with it many implications. The view has become broader. It is no longer adequate to study a site *per se*, to assign it to its period, or even to seek analogies of detail elsewhere. The prehistorian must look to its geographical and cultural relations, and his aim is rather to assign it to its proper place as an

index of cultural development and movement. His method is synthetic rather than analytic.

This change in point of view in the study of British archæology to-day was foreshadowed before the War. So long ago as the beginning of the present century, Lord (then the Hon. John) Abercromby in his studies of bronze age pottery combined a detailed examination of form and ornament with a broad view of distribution and the inferences to be drawn therefrom as to cultural and racial movement, a piece of work which for many years had a marked effect on the work of British archæologists and of which the full force is not yet spent.

At the same time, in the study of archæology, or rather prehistory, on the Continent, beginning with the Mediterranean area, much attention had been devoted to questions of distribution, interrelationship, and cultural and racial movement. In these studies, British archæologists had no small share; but when they turned to their own country, in working out their problems, they found lamentable gaps in the evidence: questions of distribution had scarcely been attacked, and there had been but few attempts to co-ordinate information. A recent writer has directed attention to how little, relatively, is really known of the Iron Age in Britain.

Fundamentally the problem, to a great extent, is one of distribution. A great advance was made immediately after the War by the appointment of an archæological officer to the staff of the Ordnance Survey Department. This has assured greater attention and care in the recording of certain classes of antiquities; but the real need is for a whole series of maps recording the location of all classes of antiquities. This covers only what is already known. How much may yet remain to be discovered is incalculable; but the aeroplane has revealed possibilities. To it we owe Woodhenge. Here the aeroplane brought to the knowledge of the archæological world a new and unsuspected type of prehistoric monument; and this is one only of the discoveries for which we are indebted to the Royal Air Force. Within the last few days, aerial photographs taken in the course of military exercises have revealed four previously unknown temporary camps along the line of Hadrian's Wall between Wallsend and Gilsland, and indications at Housesteads and Chesters point to civilian settlement of a size and plan not previously suspected. More important in the present connexion is it that these photographs suggest the lines of future research. Is it too much to suggest that training for the Royal Air Force in air photography, which can be carried out anywhere, might be combined with a systematic archæological survey of the country?

It requires no more than a superficial view of the present situation of archæological studies in Great Britain to see that the need of the moment is synthesis and organised research—investigation along lines on which information is least adequate. This involves a mobilisation of information and co-operation between the various archæological interests throughout the country. In Northern Ireland, as noted elsewhere in this issue, a movement has been initiated to record all ancient monuments within a certain area, with all obtainable information concerning them. Similar records for England, Scotland, and Wales are eminently desirable. They would form an admirable basis for the fuller archæological survey which we feel a necessity for any real advance in archæological studies. In the meantime, the Congress of Archæological Societies has published the first report of its Research Committee, which was appointed in 1929. We commend this most valuable document to all who are interested in archæological studies; for the Committee, in advocating a policy of co-operation and organised research, has enumerated for each period of prehistory the problems which it will be the task of research to solve.

The New Survey of London.

The New Survey of London Life and Labour. Vol. 1: *Forty Years of Change.* Pp. xv + 438. (London: P. S. King and Son, Ltd., 1930.) 17*s.* 6*d.*

THIS continuation of Charles Booth's Survey of London, of forty years ago, has everything to commend it. The new editor-in-chief, Sir Hubert Llewellyn Smith, quotes very aptly from Charles Booth on his title page: "Comparisons with the past are absolutely necessary to the comprehension of all that exists to-day; without them we cannot penetrate to the heart of things". The original Survey, which began to appear in 1889, was the work of one rich, enlightened, and benevolent man. It has now been taken up again by a combination of public bodies, centring in the London School of Economics, and under the direction of the sometime Permanent Secretary of the Board of Trade. The change is significant of the vast advance in organisation and socialisation which has taken place in the interval. This introductory volume testifies to many other changes in the life of the people of London; and the pleasantest thought, after reading it, is that, on the whole and in almost every

measurable aspect, the people of London are better off than when Charles Booth first surveyed them.

The various signs of this improvement, and the fundamental causes for them, are, as we might expect, either directly scientific or akin to science. We may distinguish three or four. First, the increase in organisation and its better direction to social ends. Allied with this must be mentioned the organisation of the workpeople, which has been the chief agent in securing their substantial rise in wages. Next must be placed medical and sanitary science, which has in the period made London by far the healthiest of the great cities of the world. Lastly—put first in importance by some of the contributors to the volume—comes the general elementary education of the people, which has been successfully enforced by an admirable civic organisation. So successful has this been that for the most part compulsion is now unnecessary; both parents and children now accept the school law as part of the law of Nature, and the latter are enthusiastic about it.

On each of these aspects a few words may give some idea of the contents of this most carefully executed and inspiring volume.

Organisation, especially as applied to transport, is probably the factor which has made the most palpable change in London in the forty years. Our whole present system of underground trains, with electric buses and trams, has been evolved in this time. It is the best in the world, and has altered the conditions of life more than any other single factor. Quicker transit, over longer distances, has taken the bulk of the population into fresher air and less crowded surroundings. The change has also opened the eyes of the public to the intolerable legacy of the slums which remain.

The rise in wages and the lowering of hours of work are treated in great detail and with strictly corrected statistics. Broadly speaking, and allowing for the rise in the cost of living, the workmen of London are 30 per cent better off than when the first Survey was published; and they gain this 30 per cent for a working day of about an hour less in duration. The so-called 'unskilled' have gained proportionately the larger part, but the advance is general.

The use made of this increased leisure and means is treated rather summarily in this introduction, and we shall look for a more thorough account later on. But on two other aspects the reporters are emphatic. These are health and education. The improvement in public health is so remarkable that we must give a few of the figures. Since 1880 the death-rate per thousand has been nearly halved, having gone down from a little more than 20 per thousand to a little less than 12. In the case of infants, the decrease is far greater, for the death-rate per thousand for them was in 1880 about 150, and had been more, while in the latest returns included in this book it has fallen to 68. Dr. Wheatley, who is quoted on this subject, attributes the improvement mainly to the growth of an educated public opinion. "The saving of child-life came about as soon as a generation which had passed through the primary schools had become the parents of a new generation." No doubt the accompanying fall in the birth-rate accounts for a good deal in this result. Having fewer children, mothers are freer and more determined to take the utmost care of those they have. But it is shown by the statistics that the improvement had begun before the fall in the rate, and many points in child-welfare have been sedulously inculcated in recent years by all sorts of beneficent organisations outside the schools.

If one is to criticise at all, it would be that the reporters are inclined to be somewhat too optimistic with regard to the level of education and the direct result of school-teaching. Two of their conclusions suggest this remark. One is the statement, sometimes explicit and oftener implied, that we have now achieved an 'educated' population in London, if not an educated democracy as a whole. This surely puts the advance far too high. A special inquiry, as careful and expert as this, into the education of the people of London would be a valuable and enlightening thing. It would, one fears, lead to a rather less roseate picture than is given of the definite and measurable improvements in health, wages, and transport. Connected with this point, one is inclined to surmise that the great improvement in the mortality statistics is more largely due to better sanitation and health administration, as well as the rise in the standard of living, than to the education provided by the schools. But the subject obviously is a very complicated one, and no one would wish to lessen the credit due to the teachers and to the education service generally, which, as organisation, is perhaps the most admirable thing which Great Britain has carried through in the time of this review.

Three blots disfigure the otherwise bright tableau which is unfolded. One, the most conspicuous, is what is commonly known as 'Poplarism'. Entirely within this period, the habit has grown up in certain large areas, both in London and elsewhere, of treating poor law relief as an habitual resource, in place of, or in supplement to, wages. The

growth of this evil and the recent efforts to stem it are faithfully described. The second, less rampant, but significant and disturbing, is the increase of certain classes of sexual offences amid a general and very considerable fall in crime. The third, directly connected with the growth of motoring and possibly with the employment of the police in controlling motor traffic, is an increase in burglary—not, as is sometimes supposed, in the London area itself, but in the surrounding belt which may be reached, raided, and left by the motor bandit. This is one of the incidentals of a scientific advance, and still leaves us well behind Chicago.

F. S. MARVIN.

The Life-Work of Francis Galton.

The Life, Letters and Labours of Francis Galton. By Prof. Karl Pearson. Vol. 3*a*: *Correlation, Personal Identification and Eugenics.* Pp. xiv + 440 + 44 plates. Vol. 3*b*: *Characterisation, especially by Letters. Index.* Pp. vi + 441-673 + 18 plates. (Cambridge: At the University Press, 1930.) 69*s*. net.

THE completion of this great "Life" of a great man is an achievement, and we wish to express what all interested must feel, that the library of science has been enriched in a very noble way. We venture to congratulate Prof. Karl Pearson on the success of his undertaking; he has given us a painting by a master. No doubt it has been a labour of love and not without the artist's joy; but it has meant many years of strenuous sifting and appreciating and arranging to elaborate this worthy record of the life and work of one of the most notable pioneers in the history of civilisation. Therefore, if we may be a mouthpiece, we would simply thank Prof. Pearson for this monumental work, surely never excelled in completeness, accuracy, insight, and keen judgment flashing like a two-edged sword. We have to congratulate our science that such a biographer was available and willing, for no one else could have summed up Galton's labours with such competent authority or pictured the man with such sympathetic understanding.

On the whole, we suppose, we should be glad that it has been possible to complete the work on the same grand scale throughout; and it is something to be proud of that wise generosity has helped to make it possible. In these two concluding parts (vols. 3*a* and 3*b*) there are 673 pages and 59 plates, besides beautiful frontispieces—the whole a great credit to the Cambridge University Press. The volume is expensive; but good value for the money. What the biographer says in this connexion is of refreshing interest. He points out that he has devoted to his task much of his time for twenty years, and that he made up his mind from the outset that the biography should be done to satisfy himself and without regard to traditional standards, to the needs of publishers, or to the tastes of the reading public. "I will paint my portrait of a size and colouring to please myself, and disregard at each stage circulation, sale or profit." There is a delightful breeze about this—a suggestion of one of the great masters; and the publication has been accomplished. Our only regret is that the price of volumes so monumental and magnificent is prohibitive for most of us—especially perhaps for those with youth on their side, who are naturally attracted to new movements, such as the one to which Galton gave so much of his pioneering energy.

The biographer's second reason for being anything but apologetic for the size and splendour of his volumes is that it seemed to him well worth while to gather together, once for all, everything that contributed towards a complete appreciation of Galton's labour and thought. In a short time, verification becomes difficult and documents disappear; so Prof. Pearson resolved to preserve in permanent form all that is essential. "In the centuries to come, when the principles of eugenics shall be commonplaces of social conduct and of politics, men, whatever their race, will desire to know all that is knowable about one of the greatest, perhaps the greatest scientist of the nineteenth century." So be it, and their gratitude will be added to ours. What is needed, however, since these dignified volumes are frankly too expensive for first-class minds with third-class purses, is the preparation of a relatively small volume, like the recently published admirable appreciation of Erasmus Darwin, available to all who wish to learn what this great life has to teach; and if the veteran biographer cannot do it himself, he has not to look far for one who can.

In vol. 3*a* we find (1) an account of Galton's work on correlation and the application of statistics to the problems of heredity; (2) a discussion of what Galton did with reference to finger-prints; and (3) the story of the last decade of his life and the concentration of his many endeavours to make eugenics an ideal for educated men and women. Vol. 3*b* is devoted to characterisation, especially by means of letters. Both volumes are generously and beautifully illustrated.

We wish to refer briefly to a question of terms used in reference to eugenics. If eugenics be "the study of those agencies which under social control

may improve or impair the racial qualities of future generations, either physically or mentally ", it does not seem to us that anything is gained by calling it a 'creed', still less 'a religious faith'. But Galton was very strongly of the opposite opinion. He considered various definitions, and affirmed that "the direction of the emotions and desires towards a furtherance of human evolution, recognised as rightly paramount over all objects of selfish desire, justly merits the name of a religion". His biographer corroborates this usage, for he writes: "Man has learnt how to breed plants and most inferior forms of life that are of service to him. He has yet to learn how to breed himself. When he has studied heredity and environment in their influence on man, the application of the laws thus found to the progressive evolution of the race will become the religion of each nation. Such is the goal of Galtonian teaching, the conversion of the Darwinian doctrine of evolution into a religious precept, a practical philosophy of life. Is this more than saying that it must be the goal of every true patriot?" This last question 'hits the nail on the head'. The eugenic ideal of improving the human breed is a goal, an aim, an ambition, but it is scientific, not religious. There is nothing mystical about it, as there is in all religious activity according to the great majority of its competent students. We should not have lingered over this point did not the usage sanctioned by Galton and Pearson, both so nearly perfect in precision, seem to us to be somewhat of a hindrance to the diffusion of the eugenic ideal or aim. That the eugenic endeavour should come to have an intensity comparable to that of a high religious aspiration is indeed our hope and prayer; but that is not the question before us.

As we read the story of Galton's life and labours, and recall what we read in the previous two volumes a good many years ago, we cannot repress a feeling of almost embarrassing admiration. For Galton was a genius, in the sense that he had abilities of unique pattern and at a high power of intensity, yet all regulated by indefinable wisdom, by magnanimity, and by a great kindliness. Having had unforgettable experience of this characteristic kindliness, we can understand in some measure the feelings of those who stood around Galton's grave in Claverdon churchyard in January 1911: "What we felt deeply was the personal loss of that gentle, affectionate, and modest nature, generous in thought and in practice, here bestowing an idea and there a helpful hand; rarely saying a harsh word, and often moderating the acerbity of others; taking life earnestly, but with a saving sense of humour; he would have been of earth's elect even if he had never achieved high rank in science. It was the loss of that ever-flowing spring of understanding human sympathy that we felt most bitterly." What an outstanding argument for eugenics the man was!

On those qualified to judge, Galton's work has left the impression of a mind of the first rank; and there was a characteristic freshness, retained throughout life, which enabled him to illumine whatever he touched. We must think of his contributions to medicine, evolution, anthropology, geography, psychology, heredity, and statistics—showing a marvellous many-sidedness. To this quality, so convincingly documented in these volumes, the biographer playfully referred when he took the chair at Galton's famous address to the Sociological Society in 1904 on "Eugenics, its Definition, Scope, and Aims". "If I wanted to know how to put a saddle on a camel's back without chafing him, I should go to Francis Galton; if I wanted to know how to manage the women of a treacherous African tribe, I should go to Francis Galton; if I wanted an instrument to measure a snail—or an arc of latitude—I should appeal to Francis Galton. If I wanted advice on any mechanical, or any geographical, or any sociological problem, I should consult Francis Galton." And it was not in the least that he was an incarnated encyclopædia, it was rather that he had unusual fertility, lucidity, and elasticity of mind—an ever-youthful mind, save that it grew wise.

It is not for us to pay compliments to the distinguished continuator of the work of a great initiator, but in our position for the moment as reviewer we must be allowed to express our admiration at the perspective and proportion that mark these volumes. Amid the manifoldness of recorded achievement, there is no crowding or jumble; and this is the reward granted to an artist who mixes his paints with brains. "There was a unity underlying all Galton's varied work which only reveals itself when, after much inquiry and retrospection, we view it as a whole and with a spirit trained to its modes of thought. Twenty years of almost continuous reflection on Galton's labours have enabled me to see, using his own words, the whole as a 'permanent panorama, painted throughout with equal colours', and to grasp better how great diversity of production may nevertheless be consistent with a marvellous unity in the main aim of a life." For the dominant and unifying idea of Galton's life's work was "to measure the influence of heredity on the mental and physical attributes of mankind, in order that a true knowledge of natural

inheritance might enable man to lift himself to a loftier level".

In our judgment, Francis Galton should be for ever memorable (1) as a vindicator of the rôle of statistics (in the broad sense) as an organon of research, and (2) as one of the three founders of the science of heredity. Darwin had indeed shown that the facts of heredity are amenable to scientific treatment, but the three men who laid the foundation-stones of genetics—the science behind eugenics—were Galton, Mendel, and Weismann, each with his characteristic contribution—biometric, experimental, and cytological respectively. It is, of course, of great interest that while Weismann's work was quite independent, it was anticipated by Galton in its idea of the continuity of the germ-plasm (which the biologist of Freiburg *demonstrated*), and in its scepticism as to the transmissibility of acquired characters. Galton and Mendel were both born in 1822; Weismann's year was 1834. We believe we had the honour of directing Weismann's attention to Galton's earliest papers, of which he was unaware; and at that date neither of them knew anything about the lamentably well hidden treasure of Mendelism. It meant a retardation of progress that the three foundation-layers were independent contributors rather than co-operators; but this has happened repeatedly in the history of science.

But what was Galton's chief service to mankind? It was not exactly the new method of biometry nor the scientific foundation he gave to the study of heredity. It was not even his vision of eugenic possibilities; for though this was fuller and clearer to Galton than to any previous investigator, the eugenic ideal of having a fine family is one of the oldest ambitions in the world. Galton's greatest service was in being a pioneer in thinking of man biologically. Just as Darwin, his great cousin, discovered man as an evolved species, solidary with the rest of creation, so Galton saw man as a species evolving; and if evolving, then with a progress and retrogress that can be more or less understood, and thereby more or less controlled. By application of biological laws, man may learn to breed himself as he breeds his crops and stock, though to even finer issues. That was the new idea, the new hope, the *novum organon*—to use science for life; man must learn, in Pearson's fine phrase, "to tame by science the nescient waywardness which lays waste his stock". He has learnt not a little in the moment of time since Galton died, thanks to the eugenics laboratory on one hand and eugenics societies on the other, which ought to work in the heartiest co-operation; and he will learn more rapidly whenever he cares more about it. Heaven forfend that he should learn too late, for that would be the grimmest of all ironies.

If man is to control his own evolution in the light of science, he will need all the science he can get—not of heredity alone, but also of functioning and environment as well, eutechnics and eutopias as supplements to eugenics. Since the organism is a unity, the aid of eupsychics must be also invoked; and of moral education too, even more than Galton would admit. As sociologist, Galton was more or less free from the biologisms which take the pith out of many eugenic endeavours: for it is a terrible fallacy to ignore the differentiating 'social heritage', which is as supreme as Galton's 'natural inheritance' is fundamental. Moreover, we often wonder whether the outlook of initiator and continuator alike might not have gained by recognising that we need in our eugenics more than *human* biology. For in the animal world there have been eugenic achievements strongly suggestive of heights to which man, usually so badly shackled and enmeshed, has not as yet approached. But that is another story!

Galton has been well called "a *religious* agnostic"; and here the word religious is used in its proper sense, to indicate the sending forth of tendrils towards the Supreme Reality. "Galton believed in a recondite purpose in the Universe, which we men cannot unriddle, and he urged his fellows with religious earnestness to take up the burden of their task and further develop their species in fitness to its environment. Increased vigour of mind and body appeared to him the aim of the power which we seem to discern working obscurely, and as if with difficulty, behind the apparently blind Forces of Nature." *In hoc signo laboremus.*

Liberia and the Belgian Congo.

The African Republic of Liberia and the Belgian Congo: based on the Observations made and Material collected during the Harvard African Expedition, 1926–1927. (Contributions from the Department of Tropical Medicine and the Institute for Tropical Biology and Medicine, No. 5.) Edited by Richard P. Strong. In 2 volumes. Vol. 1. Pp. xxvi+568. Vol. 2. Pp. ix+569-1064. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1930.) 67*s.* 6*d.* net.

DR. R. P. STRONG states in his introduction that the Harvard African Expedition of 1926–27 was planned, first, for the purpose of

making a biological and medical survey of Liberia, the interior of which even now, although within twelve days of Great Britain, is, as Sir Harry Johnson stated in 1906 in his book "Liberia", still the least-known part of Africa; and secondly, to cross the continent from west to east, travelling particularly through the Belgian Congo. After the survey of Liberia was completed, the expedition proceeded by sea to the Congo and up that river to Stanleyville, continuing up the Lualaba to Kabalo, then eastward to Albertville on Lake Tanganyika, afterwards travelling northward via the Lakes Rift, and eventually reaching Mombasa by way of Lake Victoria and Nairobi.

The first 200 pages of vol. 1 of this wonderfully well got up and beautifully illustrated book, dedicated to Mr. Harvey S. Firestone, are of special interest, being devoted exclusively to the Black Republic, its climate, inhabitants, agriculture, medical and social conditions, and its natural history. There are also chapters dealing with slavery and maladministration in the hinterland of Liberia which afford ample confirmation of the findings of the recent International Commission of Inquiry. Dr. Strong writes in relation to the periodic tours in the interior, of the Commissioner-General and the major commanding the frontier force, who are usually accompanied by a large number of soldiers, messengers, and others:

"Official regulations require the natives of the hinterland to furnish porters for the government. . . . The porters receive no pay. . . . After these visits the towns or villages are frequently left in at least temporary destitution, for apparently almost everything of value is taken away. Goats, poultry, and other food supplies, the few animal skins or articles of native manufacture in the town, and sometimes even the young or more attractive girls, disappear. There is no redress for this extortion. To avoid it, villages are sometimes abandoned and groups of natives abscond across the border, not always to return. This practice of raiding by the District Commissioners, however, has become more or less known. In 1926 the Liberian legislature made an investigation, in which two aboriginal native Commissioners (not Americo-Liberian) were concerned. It disclosed the fact that in the name of providing entertainment for the President, who was making a tour of the hinterland, several native Commissioners had collected from the natives, without payment, about 200 goats, 585 hampers of rice, 40 tins of palm oil, 400 chickens, and other articles of food, to the total value of $1600. Although the President found it impossible to visit the area, the Commissioners kept the food. After the investigation, the House of Representatives passed a resolution asking that the salary of one of the Commissioners he withheld until he returned the articles *to the government*, and that the other Commissioner be dismissed. Obviously, however, it is exceptional to make any excuse, such as a possible visit of the President, for such raids upon the villages."

The book is first and foremost a valuable addition to our general and detailed knowledge of the diseases of tropical Africa, west coast and central Africa in particular, their causation and transmission, as well as their histological pathology—for since the expedition returned to America a vast amount of work has been done on the material that was collected. Malaria, the most prevalent of all diseases in the tropics, and of the first economic importance, is dealt with mainly in relation to the incidence of infection in various localities. The routine malaria work carried out during the progress of the expedition affords some interesting results. "Almost no one", state Drs. Strong and Shattuck on p. 212, vol. 1, "doubts the value of the splenic index as affording a simple and rapid method of estimating the degree of malaria in some infected areas, but on the other hand it certainly does not furnish means of discovery of all malarial infections, and it would be exceedingly unwise in certain tropical districts to assume that all cases of splenomegaly are necessarily malarial in origin."

Much of the recent work on splenomegaly is summarised; yellow fever, filariasis, and other mosquito-borne diseases are usefully discussed, and again much of the recent work on these diseases is summarised for the student. During the course of the investigations in Liberia, some discoveries were made in connexion with *Onchocerca volvulus* and *Simulium damnosum*, the large black, white-footed simulium known as the 'Jinja fly', first named by Theobald from specimens collected at Jinja, near the Ripon Falls, by the reviewer, whose description of the sanguinary appearance of the bare legs of his tormented porters on the Jinja-Kampala road inspired the name *damnosum*. The Harvard Expedition's observations with reference to *Simulium damnosum* as the transmitter of *Onchocerca volvulus* are apparently the first to confirm the very important ones of Blacklock published a few months previously. The discovery of the relation of onchocerciasis to keloid formations and juxta-articular nodules is also of importance. Much space is given to yaws and syphilis, and many interesting photographs of cases met with are shown.

Though well known to the natives of the interior, human trypanosomiasis—sleeping sickness—was found to be rare in Liberia, only five cases of

trypanosomiasis being discovered, all from one district, although *Glossina palpalis* was common, and in only one tsetse fly were trypanosomes detected. Animal trypanosomiasis was also found to be rare in Liberia. In the Congo, of course, conditions were very different, and more space is devoted to the subject in dealing with that region.

In Chap. xxvi. we find useful information on economic plant diseases. No infectious disease, however, was found to affect the oil palm, which is extremely common in Liberia, much more so than in the neighbouring protectorate of Sierra Leone, and should be of great commerical importance. The question of whether monkeys may act as hosts for the malaria parasites of man is considered in Chap. xxvii., and the reader will experience a sense of relief at the realisation that there is still no evidence that malaria can be transmitted from the apes to man, although plasmodia, in some cases indistinguishable under the microscope from malaria parasites in the blood of man, are not uncommon in both monkeys and the apes. Beautiful coloured illustrations of these latter protozoa are given in Chap. xxx.

An interesting botanical report of Liberia, with some very good reproductions, concludes vol. 1.

Vol. 2 deals with the mammals and birds of Liberia, birds collected in the Belgian Congo, and medical and economic entomology. It does not contain merely lists of specimens obtained on the expedition and descriptions of new species, but also aims at mentioning all the species hitherto collected from this region, thus enhancing the value of the work from the systematic point of view.

C. CHRISTY.

Our Bookshelf.

Die Rohstoffe des Tierreichs. Herausgegeben von Ferdinand Pax und Walther Arndt. Bd. I., Lief. 4. Pp. 161-320. 12·75 gold marks. Lief. 5. Pp. 321-448. 12 gold marks. (Berlin: Gebrüder Borntraeger, 1930.)

THE first 48 pages of the fourth part of this work contain the concluding portion of the chapter on fats, and deal with (1) the occurrence, extraction, characters, and use (largely as the basis of cosmetics) of spermaceti; (2) the animal fats employed with vegetable fats in the manufacture of soap; (3) ox-gall and its uses in industry, chiefly in colour work; and (4) fossil bitumina, including asphalt and petroleum.

The remainder of the fourth part and the whole of the fifth are devoted to a consideration of the skins and membranes of animals used in commerce. Accounts are given of hides and the modes of drying them, and of the chief methods of preparing leather. The nature and varied uses of the skins of elasmobranch and other fishes and of reptiles and birds are described. Reference is made to the damage caused by 'warbles'—the larvæ of *Hypoderma*, which in Germany in 1929 was estimated to amount to nine million marks. Short accounts are given of the uses of leather in ancient and in medieval times, and of the present usage of leather by natives in different parts of the world; and a note is added on leather money,

The section on the preparation and usage of membranes derived from internal organs shows what each part of the alimentary tract—œsophagus, stomach, small and large intestine—yields in commercial products. Here is found information on the preparation of goldbeater's skin, usually made from the outer layer of the cow's cæcum; of catgut, now made from the small intestine of the sheep; and of the coverings for the vast quantity of sausages consumed, especially in Germany and Austria.

The final chapter, on furs, opens with a description of the different types and arrangement of hair, and the successive changes in the hair and its colour during the growth of the animal. This is followed by an account of the North American and Russian fur trades. A survey (unfinished) of the principal furs of commerce is arranged in systematic zoological sequence, beginning with the Monotremes.

These parts present a compact source of information which is rendered readily accessible by the use of subheadings in heavy type. In each section, historical data are given, and a bibliography is appended.

Determination of Orbits of Comets and Asteroids. By Prof. Russell Tracy Crawford. Pp. xi+233. (New York: McGraw-Hill Book Co., Inc.; London: McGraw-Hill Publishing Co., Ltd., 1930.) 20*s.* net.

IN NATURE, July 14, 1928, a note appeared on the second (reset) edition of Bauschinger's "Bahnbestimmung der Himmelskörper", with an appeal for an English translation. Bauschinger's treatise, however, had not been brought up-to-date since its first appearance in 1906, and was expensive (£3). These defects were remedied a year later in a volume by Stracke, of the Rechen-Institut in Berlin, which dealt with modern methods (except Leuschner's) including their adaptation to calculating machines. But there has been no text-book in English since Watson's "Theoretical Astronomy" in 1867. Prof. Crawford has now filled this gap in our literature. In order to keep his book within the bounds of a university text-book that can be mastered in a one year's course, Prof. Crawford has assumed a working knowledge of spherical astronomy. He develops his subject concisely, and leaves the more difficult subjects of perturbations and definitive orbits for later and more specialised study. The two methods described are a modern adaptation of Laplace's by Leuschner, and a recent modification of Gauss's by Merton. The former is the favourite method in America, but it has never been taken

up by anyone who has not been to Berkeley and studied under Leuschner himself. The latter is a modernised version of the methods in vogue on the Continent, and it is unlikely that it will yield, on this side of the Atlantic, to Leuschner's method. It offers more straightforward processes and greater facilities for checking at each stage.

The first three chapters by themselves enable a computer to prepare an ephemeris of a body from its known elements, and also to comprehend fully the motion of a body moving under a central attraction. The tables that accompany the work are printed with flat figures; American printers have not yet realised that head and tail figures only are used in the best tabular productions. Otherwise the book is well printed, and it will certainly be welcome wherever English is spoken. L. J. C.

Religion and the Reign of Science. By F. Leslie Cross. (Anglican Library of Faith and Thought.) Pp. x + 111. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1930.) Paper, 2*s*. 6*d*. net; cloth, 4*s*. net.

MR. CROSS is inclined to think that the religion and science controversy has lost interest and that this is due to a prevailing scepticism, which is having a disintegrating effect upon culture in general. People have certainly turned away from the older type of apologetic, but they are still interested in trying to see how scientific theories affect their philosophy of life; and Mr. Cross's book should help them to form intelligent opinions here. He points out that the development of science has led to "an increase in the range of casual determination, but a decrease in that of final determination". Everything had its cause, but nothing its reason. Not only miracles and prayer, but even human freedom, seemed altogether ruled out.

Mr. Cross holds that the question of freedom is more important for religion to-day than the question of miracle: "The unbelieving multitudes to-day are little helped by miracles"; and he gives a very able summary (pp. 30 and 31) of the bearing of recent physical theories upon the problem of freedom. He is not guilty, however, of trying to exploit the new physics in the interests of theological theory, and warns us that the views of such thinkers as Whitehead, Eddington, and Jeans "are highly individual, and have received little assent from the learned world". This is a very competent and useful book.

The Archæology of Kent. By R. F. Jessup. (The County Archæologies.) Pp. xiv + 272 + 13 plates. (London: Methuen and Co., Ltd., 1930.) 10*s*. 6*d*. net.

IF London justly holds first place in the "County Archæologies" on the ground of its historic importance, Kent is no less entitled to the second place for its archæological interest. It is a county peculiarly rich in relics of the prehistoric and early historic periods. It was in its plateau gravels that Benjamin Harrison found the famous eoliths over which controversy is not yet stilled; Kit's Coty House and Coldrum are amongst the most interesting of our megalithic monuments; and in Richborough, which for some years has been under excavation by the Office of Works and the Society of Antiquaries, it possesses a site which was in occupation by the Romans for practically the whole of the period of their stay in Britain. Its Saxon relics are no less interesting for the light they throw on the relations of Kent both with the Continent and the rest of England. The evidence for the various periods is passed in review by Mr. Jessup, but his account of Kent in the neolithic, bronze, and early iron ages will be particularly appreciated, as this is the first time that the detailed evidence has been brought together. His treatment of eoliths may appear a trifle over-cautious, and it would have been an advantage had he dealt more fully with the physical characters of the various races who settled in the county.

Insomnia: an Outline for the Practitioner. By Dr. H. Crichton-Miller. Pp. xi + 172. (London: Edward Arnold and Co., 1930.) 10*s*. 6*d*. net.

DR. CRICHTON-MILLER, who is the director of the Tavistock Square Clinic, is to be congratulated on his book on insomnia. It is probably the best book on the subject. It is not too long and is extremely well set out. The author has not shown any hidebound prejudices and treats each case strictly on its merits. In so many cases, there is an emotional factor at work, and until this is satisfactorily dealt with, it is quite useless giving drugs and trying to 'cure' the insomnia. In the chapter on the psychological aspect of insomnia the various views on the conflict of life are placed before us. In this chapter, Dr. Crichton-Miller is careful to point out that Jung's views are more philosophical than scientific; he is at heart a mystic. The chapters on general treatment and medicinal treatment are good, although we would like to see psychotherapeutic nurses have a training of twelve months in a mental hospital, not three to six months!

Vorlesungen über Wellenmechanik: gehalten an der Staats-Universität zu Columbus, U.S.A. Von Prof. A. Landé. Pp. iv + 132. (Leipzig: Akademische Verlagsgesellschaft m.b.H., 1930.) 9·50 gold marks.

THESE lectures are more in the nature of comments on wave mechanics than a formal treatment. This is especially true of the first three sections, on waves and corpuscles, the uncertainty principle, and quantum statistics, in which the points of similarity and dissimilarity between the old and new ideas are brought out with great clarity. Under the second head, Prof. Landé gives a neat derivation of the number of degrees of freedom in a system of stationary waves, taking as fundamental the conception of cones of radiation, a method usually explicitly avoided in this connexion. The remainder of the book contains an outline of the applications of wave mechanics on more stereotyped lines, and includes accounts of the derivation and applications of the simple wave equation, the wave mechanics of systems undergoing temporal change, and relativistic wave mechanics.

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.*]

Phenomena in a Sounding Tube.

FROM the recent papers by Mr. P. S. H. Henry [1] and others, it appears that interest is being taken in the phenomena which occur in a sounding tube. It may be well to direct attention to some results I have obtained, publication of which will shortly take place, having been delayed by illness.

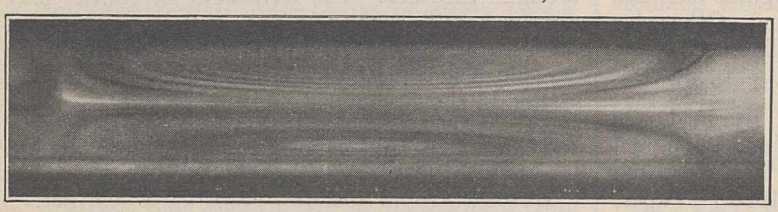

FIG. 1.—Node to antinode circulation in dust-free air.

There are two main phenomena which have been hitherto undetected in experimental work on Kundt's tube, one of which takes place in the absence of all dust and is a free circulation of the air, while the other is caused by the presence of dust particles. In general, particles of dust of the size and mass used are much too massive to act as tracing points for the air motion, but behave rather as obstacles over which the vibrating air washes, although they may partake to some extent of the motion. Particles of smoke, however, can be shown to take up the full motion of the vibrating air for ordinary acoustic frequencies, although with supersonic frequencies they do not, a point on which investigations are being carried out here. At a frequency of 1200 per second, for example, the ratio of the amplitude (or velocity) of the smoke particle to that of the air is 0·9996.

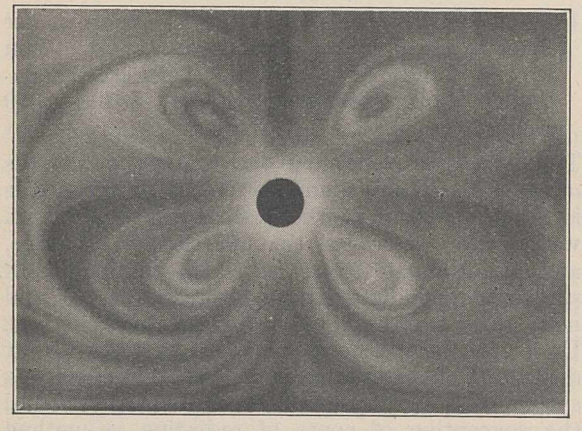

FIG. 2.—Vortex system formed round a sphere by vibrating air. The obstacle has been emphasised: otherwise the picture is an untouched print. The vertical band extending above the obstacle is a shadow, not a material bar.

Using smoke in a tube containing air set in vibration by a valve-maintained diaphragm,[2] a perfectly regular circulation of air, from antinode to node along the walls and returning down the centre of the tube, has been detected. The nature of the circulation can be clearly seen from the photograph reproduced in Fig. 1, which represents part of a long tube of 3·5 cm. diameter, the wave-length being 56·6 cm. A circulation of this kind was predicted by Lord Rayleigh,[3] who believed that something of the kind had been seen by Dvorak. What Dvorak saw, however, was a motion of large particles of quite a different nature, as will be made clear in the forthcoming publication. The lines of flow of the motion shown in Fig. 1 agree pretty closely with those that can be computed from Rayleigh's formula, the main difference being that the distance from the wall to the surface at which the direction of flow reverses is found experimentally to be 0·33 times the radius, while according to Rayleigh's calculation the figure comes out to be 0·293.

The other new phenomenon is the motion of the air caused by the presence of an obstacle, and hence by a particle of dust, the inertia of which is sufficient for there to be a large motion of the surrounding air relative to it. When certain critical conditions, suggested by application of the principle of dynamical similarity, are satisfied, a vortex system of the type represented in Fig. 2 is formed round a spherical obstacle; a similar system, modified in the general way to be expected, has been detected round a cylindrical obstacle. This is believed to be the first example of a vortex system generated by a vibrating fluid.

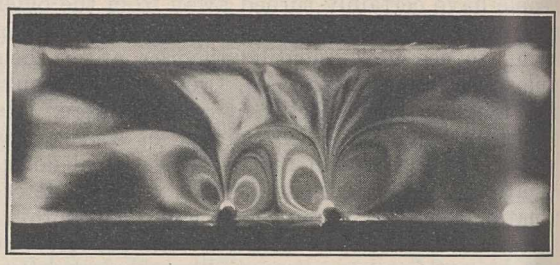

FIG. 3.—Method of formation of dust ridges by means of vortices.

Such vortices are the cause of the ridge systems which form in an excited Kundt's tube, the general method of formation of the ridges being illustrated in Fig. 3, where two cylindrical obstacles, lying on the floor of a flat tube, are shown in equilibrium. It has been found that a combination of the general circulation and of the vortex motion caused by particles can account for practically all the phenomena which take place in a dust tube.

E. N. DA C. ANDRADE.
Carey Foster Laboratory,
University College, London,
Feb. 27.

[1] *Proceedings Physical Society*, vol. 43, part 3, No. 238.
[2] NATURE, Nov. 9, 1929.
[3] "Collected Papers", vol. 2, p. 239.

Determination of the Molecular Weight of Insulin.

AT the suggestion of Dr. H. Jensen, of the Johns Hopkins University, Baltimore, an ultracentrifugal investigation of insulin has been carried out in my laboratory by Mr. B. Sjögren. A quantity of 0·25 gm. crystalline insulin was kindly put at my disposal by Dr. Jensen, and this small sample proved sufficient

for a fairly complete study of the molecular weight and *p*H-stability region of insulin.

Twelve determinations of the sedimentation of insulin in centrifugal fields 100,000 times the force of gravity at 20° C. over a *p*H-range of 3·5-12·3 showed that insulin is stable from about *p*H 4·5 to about 7·0. The sedimentation constant has a value of $3{\cdot}47 \times 10^{-13}$, which is very close to the value $3{\cdot}54 \times 10^{-13}$ previously obtained for egg albumin, and that for Bence Jones protein, namely, $3{\cdot}55 \times 10^{-13}$. When the stability range is exceeded, dissociation into low molecular products takes place. This dissociation is reversible if the substance has not been brought too far into the acid or alkaline region and has not been kept there too long.

Three determinations of the sedimentation equilibrium of insulin at a *p*H of 6·7-6·8 gave as a mean value for the molecular weight 35,100, which within the limits of experimental error is the same as that for egg albumin, 34,500, and for Bence Jones protein, 35,000. For the partial specific volume the value 0·749 was obtained. This constant also is identical with that of egg albumin and Bence Jones protein. A calculation of the molar frictional constant from the above data gives the result that the insulin molecule is spherical, which is also the case with the molecule of egg albumin and Bence Jones protein.

The sedimentation equilibrium determinations show that crystalline insulin is homogeneous with regard to molecular weight, that is, the molecules in the sample studied were all of the same weight.

The above results seem to demonstrate that insulin is a well-defined protein belonging to the same class as egg albumin and Bence Jones protein (compare NATURE, June 8, 1929, p. 871). As pointed out by Dr. Jensen in a letter to me, this fact makes it very improbable that the sythesis of insulin will ever become possible. THE SVEDBERG.

Laboratory of Physical Chemistry,
University of Uppsala,
Uppsala, Sweden, Feb. 21.

Viscosity of Electrolytes.

THE investigations of Jones and Dole [1] suggested to me the problem of studying the viscosity of strong electrolytes from the viewpoint of the theory of Debye.[2] It is well known that Debye's theory assumes that each ion is surrounded by an 'ionic atmosphere' the total charge of which is equal and opposite to the total charge of the central ion.

The ionic atmosphere has a definite thickness and in addition requires a certain time for its formation, which is called the time of relaxation. Both the thickness and the time of relaxation are dependent in a definite manner on the concentration, the valence of the ion, the temperature, and the dielectric constant of the solvent. Furthermore, the time of relaxation is a function of the mobility of the ions.

The properties of the ionic atmosphere are of great significance in a consideration of the reversible thermodynamic and irreversible conductivity processes of strong electrolytes.[3] They also make it possible to construct a picture of the irreversible mechanism that is involved in the viscosity phenomena exhibited by strong electrolytes. To illustrate this, we might consider the following case. Imagine a plane perpendicular to the axis along which the velocity of the ions is changing. If we take into consideration the successive layers above the plane, it can be shown that as a result of the electric lines of force coming from the added electric charge, a force is built up on the central ion parallel to the x axis (see Fig. 1).

The total shearing force which is produced over an area of one square centimetre lying perpendicular to the velocity gradient can be readily calculated. In making this calculation, the negative ions with their deformed ionic atmospheres must also be taken into consideration. In this case the distribution of the electric charge is complementary to the corresponding distribution of the charges in Fig. 1. This force is proportional to the velocity gradient. The proportionality factor is obtained by adding to the viscosity of the original solvent the effect due to the Coulomb forces existing between the ions.

If we call the viscosity of the electrolyte η_γ in normal concentration γ (in mols. per litre), η_0 the viscosity of the pure solvent, then I can derive the

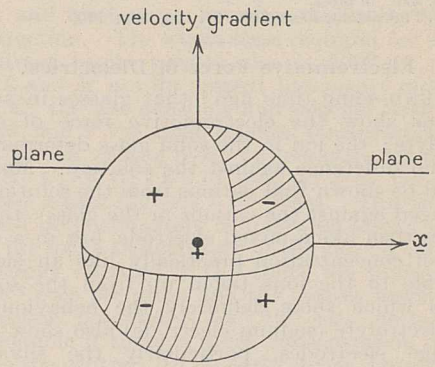

FIG. 1.

following relation theoretically which holds (or is applicable) in the case of dilute solutions:

$$\eta_\gamma = \eta_0(1 + A\sqrt{\gamma}).$$

In this expression A is dependent in a definite manner on the valence of the ion, its mobility, the absolute temperature, the dielectric constant, and the viscosity of the pure solvent η_0. For potassium chloride at 18° we obtain $A = 0{\cdot}0046$ with water as solvent. Recently Joy and Wolfenden [4] have verified this predicted value experimentally.

In this connexion it may be interesting to note that I have recently calculated the general expression for the viscosity of any simple strong electrolyte and that I have also derived the general limiting law (*Grenzgesetz*) for viscosity phenomena. The expression is the same as that indicated in the formula above, except that the coefficient A is in this case dependent in addition, in a much more complicated manner, on the mobilities and valences of both ions. I do not propose to give the expression in detail here, for it is to be published shortly.[5]

It would be very interesting to compare the theoretical results with systematic experimental studies, which will have to be carried out in the future. A systematic investigation of the viscosity of weak electrolytes as a function of concentration, etc., would also be very interesting. I believe that in this case the dependence of the viscosity on the concentration does not follow the square root law, but presumably is linear. These linear terms are also important for the more concentrated solutions of strong electrolytes. Perhaps it would be possible to develop further the exact differential equations pertaining to the problem so that this field may be explored. In doing this, it will be necessary to take into consideration the relaxation effect of the dipole molecules of the solvent on the viscosity of the solution. This has recently been calculated by Finkelstein,[6] according to whom this effect is proportional to the concentration.

Although I am at present not fully convinced as to the validity of the quantitative values calculated by Finkelstein, it nevertheless appears that some interesting explanations of the structure of electrolytic solutions are to be expected by comparison with experimental results.

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[1] Jones and Dole, *J. Amer. Chem. Soc.*, **51**, 2950; 1929.
[2] Falkenhagen and Dole, *Zeit. f. physik. Chem.*, **6**, 159; 1929: also *Phys. Zeit.*, **30**, 611; 1929.
[3] See the article by me entitled "Modern Theories of Ionisation" in the *Chemiker Kalender*, vol. 3, pp. 346-362; 1931; or my forthcoming monograph on electrolytes.
[4] Joy and Wolfenden, NATURE, Dec. 27, 1930, p. 994.
[5] *Phys. Zeit.*, in press.
[6] B. N. Finkelstein, *Phys. Zeit.*, **31**, 130, 165; 1930.

Electromotive Force of Dielectrics.

I FOUND some time ago [1] that glasses in aqueous solutions show the electromotive force of a solid electrolyte: the ion in the solid glass determines the potential difference against the solution. Moreover, it could be shown that cations from the solution were exchanged against the cations in the glass: the glass behaves then like a mixed electrode, but in a certain range of concentration practically like an electrode reversible to the ions taken up from the solution. Glasses which show definitely the behaviour of a solid electrolyte (sodium electrode) also show always exchange electrodes, particularly the silver and hydrogen electrode. Certain soft glasses show only the hydrogen electrode except in alkaline solution.

It was of interest to investigate whether other dielectrics would also show the same behaviour. With J. Hafner and lately with J. E. Ferguson, I investigated the electromotive behaviour of fused silica. In this case also we found the existence of the sodium, silver, and hydrogen electrode.

In the case of quartz, as in the case of glasses, the electromotive behaviour corresponds to the observations made when a current passes the solid.

J. E. Ferguson and I [2] have investigated during the last year the electromotive behaviour of thin paraffin films. We found also in this case the existence of sodium, potassium, hydrogen, and silver electrodes, and also (with some slight deviations, however) the existence of a calcium electrode, which we failed to find in any of the glasses investigated.

These phenomena can be understood [3] if we make the following assumption: The number of places available for cations in the dielectric is limited and constant ($=a$). Only one kind of ion, cations, are taken up by the solid, and only these ions can migrate in the solid. In the state of equilibrium the difference of potential, solid–solution, is the same for all kinds of ions present. Neglecting the number of ions given off by the solid as compared with the concentration, c, in the solution, and treating the solid phase in first approximation like a dilute solution, the following formula is obtained for two kinds of ions present:

$$E = \frac{RT}{F} ln \frac{\frac{K_1}{u_1} u_2 a}{c_1 + \frac{K_1 u_2}{K_2 u_1} c_2}$$

and ΔE the potential difference in the 'concentration cell' which alone is being measured:

$$\Delta E = \frac{RT}{F} ln \frac{c_1' + A c_2}{c_1 + A c_2} \left(A = \frac{K_1 u_2}{K_2 u_1} \right).$$

In this formula c_i are the concentrations in the solution, u_i are the mobilities in the solid phase, K_i are the integration constants in the expression for the thermodynamic potential of the ions present in the solid phase (solution tension).

In this formula all the terms can be measured directly, since also A is given by a single experiment. For permutites and certain glasses, more complicated formulæ have to be used, since the ions in the solid phase cannot be treated as independent of one another, and since the amount of ions exchanged is comparable with the concentration of the ions in the solution.

KARL LARK-HOROVITZ.
Physical Laboratory,
Purdue University,
Lafayette, Indiana,
Dec. 26, 1930.

[1] *Zeit. Physik.*, **15**; 1923.
[2] *Bull. Am. Phys. Soc.*, Nov. 1930.
[3] This formula has been used by me since 1924 for the interpretation of different experimental results. See, for example, *Bull. Am. Chem. Soc.*, April 1927, and J. W. V. Osterhout, *Bull. Nat. Res. Council*, 69, p. 193, footnote 52; 1929.

Protein Structure and Denaturation.

ASTBURY and Woods' fundamental work upon the micellar structure of the protein of wool fibres,[1] and the hypothesis they put forward as an explanation of the changes observed in the X-ray pattern when such fibres are stretched, would seem to be full of significance for protein chemistry in general.

Within the last ten years, different lines of evidence have been converging upon the view that some regularity, as regards pattern and molecular size, underlies the disordered confusion of data we possess relating to the proteins of the animal and vegetable kingdoms. The two most striking demonstrations in recent years of such uniformity are afforded by Svedberg's brilliant application of the ultracentrifuge to determine the particle mass of soluble proteins,[2] classes of 'molecular weight' 1, 2, 3, and 6 times the common factor 34,500 being distinguished, and Gorter and Grendel's demonstration [3] that under appropriate conditions soluble proteins exhibit the phenomenon of surface spreading on liquids, and that all occupy the same surface area irrespective of particle mass (1, 2, 3, or 6 times 34,500). Using Svedberg's common factor 34,500 for the basis of their calculations, the Dutch workers obtain a value for the radius of the unit particle (22·5 A.) identical with that determined by Svedberg experimentally.

The most significant feature of Gorter and Grendel's work, however, is that their results imply a loosening, brought about by the surface forces, of the cohesive attraction holding the units of the aggregated proteins together. Astbury and Woods' investigations reveal a somewhat similar, although internal, deformation of the keratin structure of the wool fibre, brought about by purely physical means. Our conceptions of the chemical reactivity of protein structures clearly need revision in an attitude of greater attention to modern valence conceptions.

One more point cannot be too clearly emphasised which is common to the essential findings of Svedberg, Astbury and Woods, and Gorter and Grendel: the changes observed by these workers are strictly *reversible*.

In conclusion, I should like to touch upon the problem of protein denaturation, and to inquire whether it is not in the direction of such work as that of Astbury and Woods that we have to look for a solution of this problem? Denaturation of proteins, which can be brought about by mechanical as well as by chemical forces, is characterised by a loss of solubility at the isoelectric point. It was always thought to be an irreversible change, but Anson and Mirsky [4] have recently demonstrated its reversible nature in

the case of globin. Some internal alteration takes place during denaturation, as evidenced by the change in reactivity of the sulphur groups,[5] but neither acid or base binding capacity [6] nor osmotic pressure [7] are affected—that is to say, there is no scission. Clearly, loss of isoelectric solubility must be due to change in some internal tautomeric configuration.

It is difficult to avoid the suggestion that a change, similar to that postulated by Astbury and Woods in explanation of the behaviour of the stretched and unstretched wool fibre, may in reality be the essential happening attending denaturation. The –CO–NH– group possesses strong polarity, but, by the rearrangement of peptide linkages into what are virtually closed ring systems, affinity for water would be enormously diminished. At present there exists no satisfactory hypothesis offering an explanation of denaturation. Such a scheme as the above may reasonably be entertained until further evidence can be brought forward of a chemical or physico-chemical nature which will throw more light upon the problem. Considering the remarkable and wholly unexpected results, mentioned above, of Gorter and Grendel, working upon protein surface films, it would seem that quantitative data bearing upon denaturation is likely to be obtained most readily by studies having a similar approach. The forces at play within the liquid and at the interface possess no mean magnitude. They are, however, susceptible of more precise control and exact manipulation than those involved in, let us say, heat coagulation or the application of vigorous chemical reagents. From a study of the surface phenomena exhibited by proteins under varying conditions, coupled possibly with an application of the X-ray method to films of such proteins as can be made to give readily detectable diffraction photographs,[8] a solution not only of the denaturation process but also of the structure of native proteins may, in the future, be obtained.

CLAUDE RIMINGTON.
Biochemical Department,
Wool Industries Research Association,
Leeds, Feb. 13.

[1] Astbury and Woods, NATURE, **126**, 913; 1930.
[2] Svedberg, *Koll. Zeit.*, **51**, 10; 1930.
[3] Gorter and Grendel, *Proc. Acad. Sci. Amsterdam*, **32**, 770; 1929.
[4] Anson and Mirsky, *J. Gen. Physiol.*, **13**, 469; 1930.
[5] Harris, *Proc. Roy. Soc.*, B, **94**, 426; 1923.
[6] Booth, *Biochem. J.*, **24**, 158; 1930.
[7] Huang and Wu, *Chinese J. Physiol.*, **4**, 221; 1930.
[8] Ott, *Kolloidchem. Beih.*, **23**, 108; 1926.

Stellar Structure.

THE current argument against Helmholtz's contraction hypothesis concerning the origin of the sun's heat may be summarised as follows. The gravitational potential at a point within the sun is of the order of magnitude of its value at the surface, 2×10^{15} c.g.s. units. Thus contraction may have supplied energy 2×10^{15} ergs per gram of the sun's mass. The sun now radiates 1·9 ergs per second for each gram of its mass. Further, the earth's crust has been solid for at least $1{\cdot}5 \times 10^9$ years, during which time the sun may have radiated 9×10^{16} ergs for each gram of its mass. Hence "it appears that the Helmholtz contraction-hypothesis cannot account for more than about two per cent of the energy which has been radiated by the sun during the earth's life" (Jeans, "Astronomy and Cosmogony", p. 106). Further, there is astronomical evidence that the whole life of the sun has been at least of the order of 10^{13} years.

It seems to have been overlooked that modern theories concerning the internal temperature and density distribution in the stars very much weaken, if they do not quite destroy the above argument. If, following Milne,[1] we suppose that the mass of the star is much concentrated towards the centre, the first part of the above argument loses its force. Fifty times as much energy can be accounted for. The longer time period of 10^{13} years may be due in part to the sun's not having in the past radiated so much as it does at present.

If the opacity of the stellar material varies as $T^{-\frac{1}{2}}f(\rho/T^3)$, where ρ is the density and T the temperature (the only theoretical formula in the field is of this form), it is possible that gaseous spheres of such material should contract to homologous density distributions and obey Lane's law. Such spheres can exist possessing any mass, radius, and luminosity within certain limits, though, as I have shown,[2] this homologous contraction is a very special case. The mass, radius, and luminosity, however, determine the rate of contraction. The whole time required for the star to contract to its present size is $2(3R - C_v)MT/L$, where L and M are its present luminosity and mass, R and C_v the gas constant and specific heat of the material, and T the mean internal temperature.

For the sun, taking mean temperature 10^9 degrees, and $(3R - C_v)$ to be $2{\cdot}5 \times 10^8$ ergs per gram per degree, this gives a past life of 8×10^9 years. This would be increased proportionately if, following Milne, we estimated the mean temperature of the sun higher. The total energy radiated in the above life works out at $2{\cdot}4 \times 10^{17}$ ergs per gram and the corresponding mean gravitational potential is $4{\cdot}8 \times 10^{17}$ c.g.s. units, not at all impossible if there is much concentration of mass towards the centre. In its early stages, however, the contraction would have been much slower, since, for smaller T, R would have been larger, and the opacity also would have been larger than that given by the above formula. Indeed, opacity varying as $T^{-1}f(\rho/T^3)$ gives an infinite time scale.

Helmholtz's hypothesis appears, therefore, by no means to be untenable.

L. H. THOMAS.
Department of Physics,
Ohio State University,
Feb. 6.

[1] NATURE, Aug. 16, 1930, p. 238.
[2] *Monthly Notices of the Royal Astronomical Society*, November 1930, p. 122.

Replacing the Telephone by a Loud Speaker in Conductivity Measurements.

IT seems improbable that nobody should have ever tried replacing the telephone by a loud speaker in conductivity measurements, but I have never heard of it, nor read anything about its possibility and advantages; I will, therefore, describe it very briefly, as I feel convinced that it represents a real improvement over the customary procedure.

It consists simply in a two-stage amplifier, with a factor of amplification of about 500, connected to a Kohlrausch bridge for measuring electrolytic conductivity, instead of the usual telephone, which is replaced by loud speaker. If, instead of a buzzer, a shielded oscillator is used, and if all the leads are lead covered and properly earthed, the apparatus can be adjusted to give a musical note of variable intensity which permits the determination of the minimum sound much more easily, agreeably, and even a little more accurately than with the telephone. I have found it a great improvement, and I hope this letter will encourage those interested in resistance measurements to try this scheme, which possibly they have not used before simply because they were doubtful about its advantages.

LECOMTE DU NOÜY.
Institut Pasteur, Paris,
Feb. 16.

The Nature of the Virus Principle in Mosaic Disease.

DURING the course of investigations designed to determine the nature of the infective principle present in the virus of tomato mosaic, a bacterial growth showing various forms was isolated. Stained smears prepared from this showed so many bacteria in a state of breakdown that the phenomenon seemed worth examining further.

The original isolations were prepared as follows. Pieces of tomato stem taken from plants showing symptoms of mosiac disease and 'stripe' disease, were sterilised on the outside with calcium hypochlorite, and inserted into tubes of potato agar. No growth resulted for ten weeks; but in the twelfth week three tubes showed a grey-brown bacterial growth on the agar round the piece of tomato tissue.

Stained smears showed small clear areas (Fig. 1) at a magnification of 150. (In the reproduction, all the illustrations have been reduced to two-thirds of their original size.) When examined at a magnification of 1250 these areas appeared as in Fig. 2. The bacterial cells had been destroyed, leaving a granular deposit with deeply staining fragments strongly resembling minute organisms. At other portions of the smears (Fig. 3), certain cells were seen to be much swollen and speckled with minute darkly staining granules. Cultures of the original growth were emulsified with water and filtered through a sterile Chamberland *L*3 filter. When added to a broth culture of the original growth which had been freed so far as possible from 'phage', some slight clearing and diminution of the number of bacteria resulted.

In view of the conditions under which the original isolations were obtained, it seemed possible that the bacteriophage principle present in the cultures might be the active virus of mosaic disease present in the tomato tissue from which the isolations were prepared.

Consequently, a quantity of virus was extracted from a tomato plant originally inoculated with the virus of *Aucuba* mosaic disease, but which, since inoculation, had also developed symptoms of 'stripe' disease. Portions of the virus which had passed through *L*3, *L*5, and *L*7 filters under aseptic conditions were tubed separately. These were added in 1 c.c. lots to turbid potato broth cultures of the original growth which had been freed so far as possible from 'phage'. In 24 hours, the tubes receiving filtrates from the *L*3 and *L*5 filters showed slight clearing; and in 48 hours, there was definite clearing of these tubes, and in some cases very slight clearing and browning where the filtrate from an *L*7 filter had been added. Microscopic examination of drops from the cultures showed an appreciable diminution of bacterial numbers accompanied by apparent fragmentation when the filtrates from *L*3 and *L*5 filters were added. Poured plates confirmed this observation.

Potato broth tubes to which *L*3 filtrate of healthy tomato juice was added remained turbid, and neither decrease in the number of bacteria present nor change of form have been observed. The action of the virus seems limited to certain organisms, for when added to mixed broth cultures prepared from soil and horse manure, no obvious clearing or browning resulted.

In view of these results, which have been repeatedly obtained, it is suggested that the principle causing mosaic disease of the tomato is of the bacteriophage type, which, in the first place, enters the plant with the organism it parasitises in Nature and, becoming adapted to life within the tissues of the tomato plant, causes the symptoms now associated with mosaic disease.

If this view be correct, its implications in the study of virus diseases are considerable.

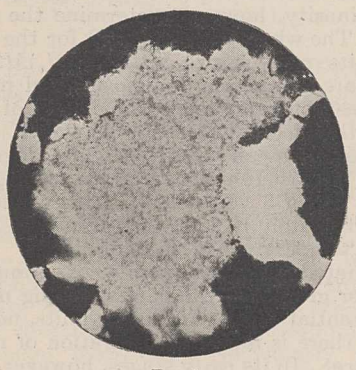

FIG. 1.

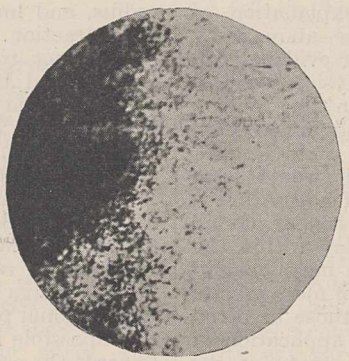

FIG. 2.

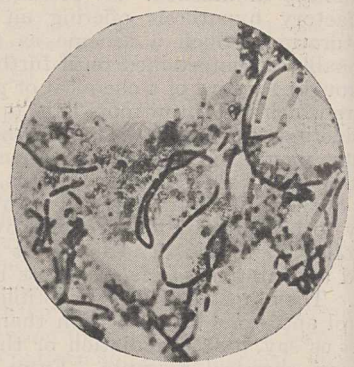

FIG. 3.

W. F. BEWLEY.
Experimental and Research Station,
Cheshunt, Herts, Mar. 5.

Hardening of *Moti*, a Japanese Rice Food-stuff.

IN the course of my researches on the mechanism of the setting and hardening of cement, and on account of the similarity of the problems involved, I have investigated also the problem of the hardening of *moti*, a Japanese rice food-stuff. Glutinous rice, previously steamed with special apparatus, is made into *moti* by pounding. In the air, it hardens into a stone-like mass. The results I have obtained so far are as follows:

(1) The hardening phenomenon occurs in two ways: (*a*) It may be due to desiccation, that is, the water in the *moti* goes off into the air, the result being the formation of a stone-like mass; or (*b*) it may be due to internal changes. For example, when freshly prepared soft *moti* is preserved under paraffin, although desiccation is thus prevented, the *moti* hardens, but to a somewhat soft mass. This mass hardens further on exposure to the air, cracking and forming a stone-like mass.

(2) By differential thermal analysis in a specially designed vessel, during both cooling and heating, *moti* shows at 63·5° C. a transition point. This change is reversible. The transition point does not appear with freshly prepared *moti*, but it appears with *moti* which has been cooled once in a hermetically sealed vessel.

(3) J. R. Katz (*Zeit. physik. Chem.*, A, **150**, 37; 1930, etc.) suggested a transition point at about 60° C. in the staling process of bread, and thinks the existence of this point is the cause of bread becoming stale. So far as *moti* is concerned, this does not

hold good, although it has some relation to the cause of the hardening of *moti* referred to in (1). *Moti*, when once hardened, can begin to soften at a temperature somewhat below the transition point, and the water of *moti* is connected with its hardness. These facts show that the constitution below and above the transition point is not the only factor in the determination of hardness.

(4) My views (*J. Phys. Chem.*, **31**, 933; 1927: *Zement*, **19**, 842; 1930) on the mechanism of the setting and hardening of cement are to a great extent applicable also to the hardening process of *moti*. In brief, the hardening is due to the decrease of free water in the system. In the case (1*a*) above, free water in *moti* escapes to the exterior. In the case (1*b*), free water which exists at higher temperatures loses its freedom in cooling, becoming water of crystallisation, adsorbed water, etc. It may be that the transition point 63·5° C. is connected with the water of crystallisation. As to the water of crystallisation in starch, the opinion of St. v. Náray-Szabó (*Zeit. physik. Chem.*, A, **151**, 420; 1930) is suggestive.

Details of this work will appear in the *Scientific Papers* of this Institute.

TUTOMU MAEDA.

The Institute of Physical and Chemical Research,
Hongo-Komagome, Tokyo,
Japan, Jan. 31.

Geo-electrical Prospecting.

IN my article published in NATURE of Jan. 3 of this year, entitled "Geo-electrical Prospecting by A.C. Bridge Methods", I stressed a disadvantage of the well-known A.C. equipotential line method of prospecting, which is sometimes so serious as to preclude the use of the method altogether. The difficulty arises from the fact that large out-of-phase components occur in the neighbourhood of the more highly conducting ore-bodies and that in such circumstances it is impossible to locate equipotential points with any degree of accuracy. In extreme cases there are no distinguishable minima from which the general trend of the current distribution may be determined.

I am writing to direct attention to a means of overcoming this difficulty which was recently suggested to me by D. C. Gall, who at the time was visiting one of my field parties. He proposed that a small search coil should be placed in series with the detecting circuit, which usually consists of a pair of pointed rods connected by 50 feet or so of wire to an amplifier and headphone. Since the e.m.f. induced in the coil will be in quadrature with the current, whereas that in the ground is approximately in phase with the current, it was to be expected that by suitably orientating the search coil it would be possible to balance the out-of-phase component and so locate the *in phase* equipotential points with precision.

Mr. Gall's suggestion has now been tried out and has proved most satisfactory, and there can be no doubt that it constitutes an improvement in the equipotential line method which will prove of great practical value. In the tests recently carried out, the coil was permanently attached to the amplifier box on the back of the operator. The latter, by slightly adjusting the position of his body, can quickly bring the coil into such a position that the equipotential points may be accurately located on the ground; complete silence being observed in the telephones.

A. BROUGHTON EDGE.

Australia House,
Strand, London, W.C.2,
Mar. 17.

Enumeration of Magic Squares of the 5th Order.

A					*B*					*C*				
25	8	5	24	3	25	21	2	7	10	15	18	6	12	14
7	16	9	14	19	17	1	22	16	9	16	1	22	21	5
6	11	13	15	20	14	18	13	8	12	8	20	11	3	23
4	12	17	10	22	3	20	4	15	23	9	2	19	25	10
23	18	21	2	1	6	5	24	19	11	17	24	7	4	13

In NATURE of Oct. 17, 1925, p. 573, I gave the above, but I was not then able to give the number of squares of *B* and *C*. I can now complete this. *A* has a 'Heart' magic in its 3 rows, 3 columns, and 2 diagonals, and with its 21 positions inside a square of 5th order has 649,168 squares. *B* has a 'Heart' with only its 3 rows, 3 columns magic, and with its 21 positions of all proportions from 52/13–26/39 has 720,388 squares. *C* has a 'Heart' without the number 13, and in its 18 positions has 3656 squares.

Including all types of squares thus far, I have brought the grand total of magic squares of 5th order, whose 5 rows, 5 columns, and 2 diagonals are magic, to 1,623,768. One type only has one solitary square, but this type can be transformed by inversion into three other types, with their complementary squares of the proportion 52/13, each having a solitary square. I give it as unique:

(9)	(5)	25	(12)	14
(10)	(13)	19	(3)	20
(7)	(8)	16	(11)	23
24	17	1	21	2
15	22	4	18	6

Propn. 26/39.

J. C. BURNETT.

Barkston,
Nr. Grantham, Lincs,
Feb. 6.

Climatic Control in the Reproductive Cycle.

IN my letter in NATURE of Feb. 7, p. 200, entitled "Embryology and Evolution", I referred to a correlation between magnetic solar radiation and the reproduction of fur-bearing animals. Statements to the effect that such a correlation has been proved to exist are frequent, and are also found in certain text-books, but there seems to be considerable doubt as to their validity.

I have, therefore, sought to obtain reliable evidence on this subject, and I am indebted to the Governors and Committee of the Hudson's Bay Company, and to Mr. Charles Elton, of Oxford, for information which is of value in showing that such a correlation was originally suggested by Mr. Elton in 1924 as an *hypothesis* only, and that it has erroneously been elevated gradually by others to the rank of fact.

I am informed by the Hudson's Bay Company that its trading operations are not based on the indications of sunspot activity nor on those of other meteorological conditions; while Mr. Elton's view is that though sunspot influence has to be ruled out definitely, there is, nevertheless, some proof of climatic control in the reproduction cycle of fur-bearers.

The phenomenon of photoperiodicity in plants might well be substituted in my original argument as an example of an external control in the activities of the living cell.

MALCOLM E. MACGREGOR.

Wellcome Field Laboratory,
Wisley, Surrey.

Oceanographical Expedition of the *Dana*, 1928–1930.

By Prof. JOHANNES SCHMIDT, Ph.D., D.Sc.,
Carlsberg Laboratory, Copenhagen, Leader of the Expedition.

IN NATURE of Dec. 29, 1928, Prof. D'Arcy W. Thompson gave an outline of the plans and scope of this expedition on board the Royal Danish Research Ship *Dana*. This vessel, with its experienced master, Captain G. Hansen, and staffed by officers of the Royal Navy, was placed at the disposal of the expedition by the Danish Government. The cost of the expedition however, was defrayed by the Carlsberg Foundation, the largest scientific fund in Denmark; hence the official title: "The Carlsberg Foundation's Oceanographical Expedition round the World 1928–30 under the Leadership of Professor Johannes Schmidt".

Admiral H.R.H. Prince Valdemar of Denmark was patron of the expedition, and it was controlled by a committee, the presidents of which were the late Prof. C. H. Ostenfeld and Prof. A. B. Drachmann, president of the Carlsberg Foundation; G. C. Amdrup, Vice-Admiral of the Royal Danish Navy, was vice-president of the committee.

It was my good fortune to have among the scientific workers several colleagues from my earlier expeditions, the zoologists Dr. P. Jespersen, Dr. Å. V. Tåning, and Mr. A. F. Bruun, the physicists Dr. J. N. Nielsen and Mr. Helge Thomsen, and the botanist Prof. Ove Paulsen; the botanist Mr. E. Nielsen also took part in the expedition. Further, two Danish zoologists, Dr. Th. Mortensen and Dr. R. Spärck, spent some time on board engaged in bottom work, the former at St. Helena and the Canaries, the latter in the Mediterranean.

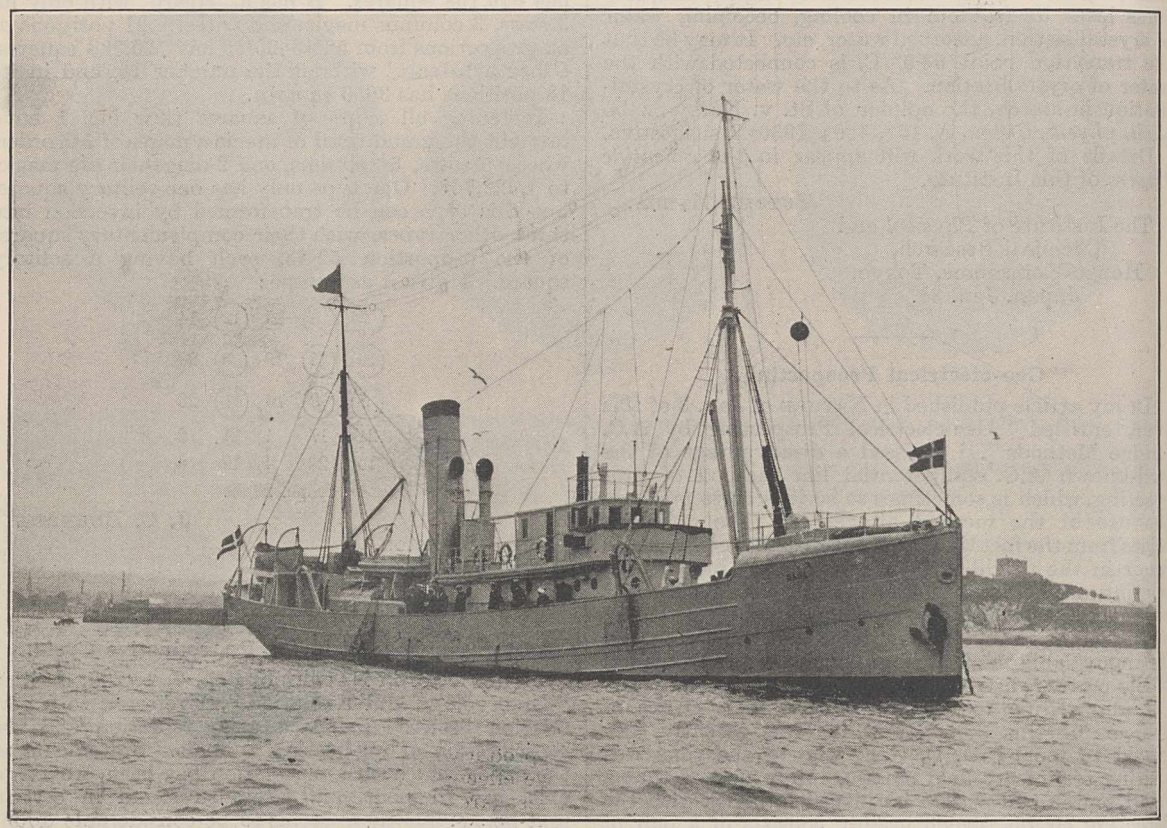

Photo.] [*The Times.*

FIG. 1.—Royal Danish Research Ship *Dana* (360 tons), at anchor in Plymouth Roads, June 21, 1930, on her return from the circumnavigation expedition.

Prof. D'Arcy Thompson has already noted in detail one of the main tasks of the expedition, namely, an investigation of the life-history of the Indo-Pacific fresh-water eels (*Anguilla*), in similar fashion to the work I had already carried out in the case of the North Atlantic fresh-water eels. What I propose to do here is to give a brief account of the main points in the working methods and plans of the expedition, and then give two illustrations of the results, one drawn from the biological side, the other from the hydrographic side; the latter has been prepared by my colleague, Mr. Helge Thomsen.

The expedition occupied two years. The *Dana* left Copenhagen on June 14, 1928, and after circling the globe in a westerly direction, returned home on June 30, 1930. The total number of stations amounted to 661, and the distance covered was 65,000 miles, with a coal consumption of 3358 tons. It should be mentioned that the

Dana, through her short-wave radio station, was in direct communication with the Copenhagen station during the whole expedition; even at the antipodal region near New Zealand the communication was perfect.

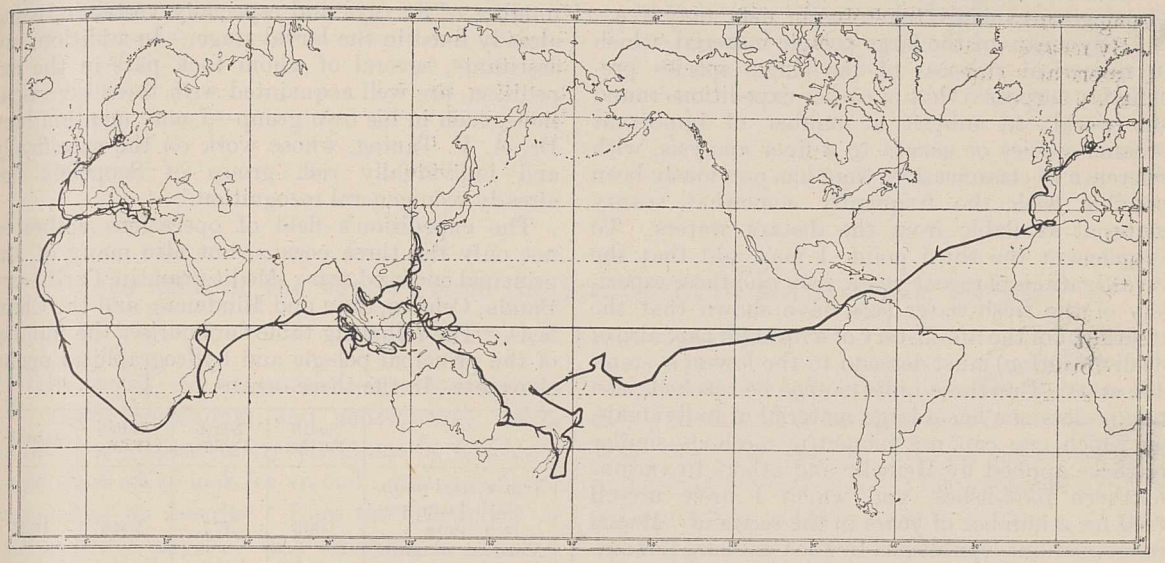

FIG. 2.—Route of the *Dana* round the world, June 14, 1928–June 30, 1930.

The route mapped with regard to the eel investigations was carried out almost completely according to plan; but owing to the limited coal capacity of our small vessel, we did not succeed in visiting all the regions in the Pacific and Indian Oceans that had been included in the scheme. The chart (Fig. 2) shows the course of the *Dana* round the world. It ran in the main parallel with the equator, except in the western Pacific and on the last lap, where it turned vertical to the equator from the Cape of Good Hope homewards.

The object of the expedition was not to bring home collections of zoological rarities. The main general task was to study the distribution of the commonest oceanic species and genera in the three great oceans, and—having regard for the physical and chemical conditions under which they live—to seek some understanding of the factors concerned in this actual distribution and to make some contribution to their life-histories.

Whilst the expedition of the *Dana's* great predecessor, the *Challenger*, was chiefly concerned with the investigation of the bottom and its fauna, our expedition was in special degree a pelagic expedition. We investigated especially the upper and middle water layers and their inhabitants, and as we had the best pelagic fishing apparatus of the present time at our disposal, I venture to hope that our results will form, to a not inconsiderable extent, a supplement to those of the *Challenger* expedition, in which the pelagic collections played a more subordinate part.

The most characteristic features of the working methods and plans of the *Dana* expedition may be summarised in three groups:

1. With the aid of the most efficient apparatus, to obtain a very large material, rich in individuals, of the pelagic life in the different depths of the various oceans.

2. With the aid of simultaneous, methodical

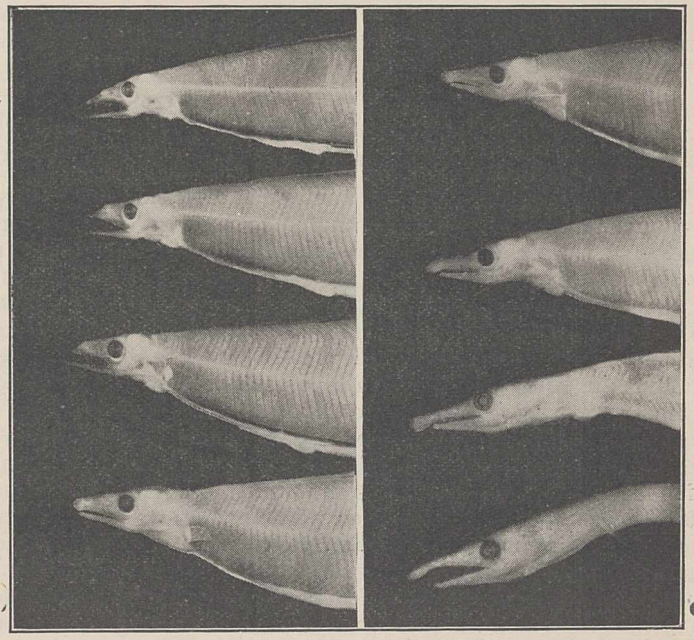

FIG. 3.—Metamorphosis of *Nessorhamphus ingolfianus*, Johs. Schmidt. Specimens from the Sargasso Sea, showing transformation from the larval to the eel stage. Photo A. F. Bruun.

a. Larval stage 67 mm.		*e*. Metamorphosis stage 84 mm.	
b. Metamorphosis stage 71 mm.		*f*. ,, ,,	78·5 mm.
c. ,, ,,	77 mm.	*g*. ,, ,,	83 mm.
d. ,, ,,	82 mm.	*h*. ,, ,,	88 mm.

investigations on the physical and chemical composition of the different water layers, to obtain data which would permit us to conclude under what environmental conditions each single one of the millions of pelagic organisms, taken in our nets, may live.

3. By means of the large pelagic material, which in numerical richness of the single species presumably surpasses that of earlier expeditions round the world, to subject a number of important oceanic species or genera to a finer analysis, with reference to classification, than has previously been possible with the frequently somewhat scanty material available from the distant waters. To supplement the third point, I may add that the investigations of recent years, *inter alia* those especially of the fresh-water eels, have shown that the treatment of the life-history of a form (in part also of its distribution) must descend to the lowest systematic units. But these units cannot be reached, as a rule, unless one has a large material of individuals, on which one can use biometric methods similar to those applied by Heincke and others to various northern food-fishes, and which I have myself used for a number of years in the series of "Racial Investigations" published by the Carlsberg Laboratory since 1917.

I nourish, therefore, the hope that our large and rich material from the three oceans, dealt with in this manner and from this point of view, may contribute new and important information regarding the species and genera of the pelagic fauna, their distribution in the oceans, their dependence on environmental conditions, and their life-histories. I refer here specially to the fishes which seem in marked degree suitable to biometric treatment, not least because the numerous larvæ can often be included in the investigation—several of the principal characters for the finer analysis, such as number of fin rays and especially vertebræ, being already fixed in the larval stage. In addition, my assistants, several of whom took part in the expedition, are well acquainted with these investigations, each in his own group—I may mention here Dr. Å. V. Tåning, whose work on the specifically and individually rich group of Scopelids has already won general recognition.

The expedition's field of operations embraced not only the three oceans, but also many of the principal enclosed seas; Mediterranean, Caribbean, Banda, Celebes, Sulu and Mindanao, and the China Seas. The following table summarises the number of the principal pelagic and hydrographical operations, etc., in the three oceans:

	South Pacific.	North Pacific.	Indian Ocean.	Atlantic.
Horizontal hauls with large pelagic nets .	606	377	1046	1034
Vertical hauls with silk nets	162	97	74	161
Deep sea water samples .	1110	763	917	1383
Echo soundings	2025	896	2215	3064

It will naturally take some time before the large amount of material can be worked out fully, but a few examples of the results of the expedition may already be given.

(*To be continued.*)

Centenary of William Symington.

By Eng.-Capt. EDGAR C. SMITH, O.B.E., R.N.

THE invention of the steam boat, or rather the application of the steam engine to the propulsion of vessels, the successful solution of which involved many problems, will always remain one of the great landmarks of human progress. On no other single project of the same nature, perhaps, was time and thought, energy and wealth, expended so lavishly, and the recognition of the labours of its inventors is, therefore, a moral obligation. Many of the projectors of steam navigation are known to us only by their patents or pamphlets, some are remembered for their ingenious suggestions and inventions, and a few by their persistent efforts to achieve what the majority of their fellows thought impracticable. "Crazy Rumsey" and "Fulton's Folly" are but two of the epithets which remind us of the scepticism the pioneers had to face. But neither derision nor opposition, failure nor disappointment, loss of health nor wealth, could stay the hand of progress. There was always someone to step into the ranks to take the place of the fallen until the final goal was reached.

"Generally what is usually called an invention", said the late Sir Charles Parsons, "is the work of many individuals—each one adding something to the work of his predecessors." This was true only to a limited extent in the case of the steam boat, for the experiments of the Marquis de Jouffroy in France, of Fitch, Rumsey, Stevens, and Fulton in the United States, and of Miller, Symington, Stanhope, and Bell in Great Britain, were largely independent of each other. Steam navigation as a regular means of transport is usually associated with the *Clermont* of Fulton and the *Comet* of Bell, built respectively in 1807 and 1812, but, as a matter of fact, the problem had already been completely solved in 1802 by Symington when he engined the *Charlotte Dundas*, and it was a cruel stroke of fate which robbed him of the fame which should have made him known as the 'father of steam navigation'. The machinery he placed in the *Charlotte Dundas* was not surpassed in simplicity and suitability for fifty years; it was far superior to that used by any of his predecessors, or even that supplied by the famous firm of Boulton and Watt for Fulton's *Clermont*. If, therefore, he is denied the title of the 'father of steam navigation', no one can withhold from him the name of the 'father of marine engineering'.

Symington, the centenary of whose death occurs on Mar. 22, was born in the mining village of Lead-

(*Continued on p.* 455.)

Supplement to NATURE

No. 3203 MARCH 21, 1931

The End of the World: from the Standpoint of Mathematical Physics.*

By Sir ARTHUR S. EDDINGTON, F.R.S.

THE world—or space-time—is a four-dimensional continuum, and consequently offers a choice of a great many directions in which we might start off to look for an end; and it is by no means easy to describe "from the standpoint of mathematical physics" the direction in which I intend to go. I have therefore to examine at some length the preliminary question, Which end?

SPHERICAL SPACE.

We no longer look for an end to the world in its space dimensions. We have reason to believe that so far as its space dimensions are concerned the world is of spherical type. If we proceed in any direction in space we do not come to an end of space, nor do we continue on to infinity; but, after travelling a certain distance (not inconceivably great), we find ourselves back at our starting-point, having 'gone round the world'. A continuum with this property is said to be finite but unbounded. The surface of a sphere is an example of a finite but unbounded two-dimensional continuum; our actual three-dimensional space is believed to have the same kind of connectivity, but naturally the extra dimension makes it more difficult to picture. If we attempt to picture spherical space, we have to keep in mind that it is the *surface* of the sphere that is the analogue of our three-dimensional space; the inside and the outside of the sphere are fictitious elements in the picture which have no analogue in the actual world.

We have recently learnt, mainly through the work of Prof. Lemaître, that this spherical space is expanding rather rapidly. In fact, if we wish to travel round the world and get back to our starting-point, we shall have to move faster than light; because, whilst we are loitering on the way, the track ahead of us is lengthening. It is like trying to run a race in which the finishing-tape is moving ahead faster than the runners. We can picture the stars and galaxies as embedded in the surface of a rubber balloon which is being steadily inflated; so that, apart from their individual motions and the effects of their ordinary gravitational attraction on one another, celestial objects are becoming farther and farther apart simply by the inflation. It is probable that the spiral nebulæ are so distant that they are very little affected by mutual gravitation and exhibit the inflation effect in its pure form. It has been known for some years that they are scattering apart rather rapidly, and we accept their measured rate of recession as a determination of the rate of expansion of the world.

From the astronomical data it appears that the original radius of space was 1200 million light years. Remembering that distances of celestial objects up to several million light years have actually been measured, that does not seem overwhelmingly great. At that radius the mutual attraction of the matter in the world was just sufficient to hold it together and check the tendency to expand. But this equilibrium was unstable. An expansion began, slow at first; but the more widely the matter was scattered the less able was the mutual gravitation to check the expansion. We do not know the radius of space to-day, but I should estimate that it is not less than ten times the original radius.

At present our numerical results depend on astronomical observations of the speed of scattering apart of the spiral nebulæ. But I believe that theory is well on the way to obtaining the same results independently of astronomical observation. Out of the recession of the spiral nebulæ we can determine not only the original radius of the universe but also the total mass of the universe,

* Presidential address to the Mathematical Association, delivered on Jan. 5.

and hence the total number of protons in the world. I find this number to be either 7×10^{78} or 14×10^{78}.* I believe that this number is very closely connected with the ratio of the electrostatic and the gravitational units of force, and, apart from a numerical coefficient, is equal to the square of the ratio. If F is the ratio of the electrical attraction between a proton and electron to their gravitational attraction, we find $F^2 = 5{\cdot}3 \times 10^{78}$. There are theoretical reasons for believing that the total number of particles in the world is αF^2, where α is a simple geometrical factor (perhaps involving π). It ought to be possible before long to find a theoretical value of α, and so make a complete connexion between the observed rate of expansion of the universe and the ratio of electrical and gravitational forces.

Signposts for Time.

I must not dally over space any longer but must turn to time. The world is closed in its space dimensions but is open in both directions in its time dimension. Proceeding from 'here' in any direction in space we ultimately come back to 'here'; but proceeding from 'now' towards the future or the past we shall never come across 'now' again. There is no bending round of time to bring us back to the moment we started from. In mathematics this difference is provided for by the symbol $\sqrt{-1}$, just as the same symbol crops up in distinguishing a closed ellipse and an open hyperbola.

If, then, we are looking for an end of the world—or, instead of an end, an indefinite continuation for ever and ever—we must start off in one of the two time directions. How shall we decide which of these two directions to take? It is an important question. Imagine yourself in some unfamiliar part of space-time so as not to be biased by conventional landmarks or traditional standards of reference. There ought to be a signpost with one arm marked 'To the future' and the other arm marked 'To the past'. My first business is to find this signpost, for if I make a mistake and go the wrong way I shall lead you to what is no doubt an 'end of the world', but it will be that end which is more usually described as the *beginning*.

In ordinary life the signpost is provided by consciousness. Or perhaps it would be truer to say that consciousness does not bother about signposts; but wherever it finds itself it goes off on urgent business in a particular direction, and the physicist meekly accepts its lead and labels the course it takes 'To the future'. It is an important question whether consciousness in selecting its direction is guided by anything in the physical world. If it is guided, we ought to be able to find directly what it is in the physical world which makes it a one-way street for conscious beings. The view is sometimes held that the 'going on of time' does not exist in the physical world at all and is a purely subjective impression. According to that view, the difference between past and future in the material universe has no more significance than the difference between right and left. The fact that experience presents space-time as a cinematograph film which is always unrolled in a particular direction is not a property or peculiarity of the film (that is, the physical world) but of the way it is inserted into the cinematograph (that is, consciousness). In fact, the one-way traffic in time arises from the way our material bodies are geared on to our consciousness:

> "Nature has made our gears in such a way
> That we can never get into reverse".

If this view is right, 'the going on of time' should be dropped out of our picture of the physical universe. Just as we have dropped the old geocentric outlook and other idiosyncrasies of our circumstances as observers, so we must drop the dynamic presentation of events which is no part of the universe itself but is introduced in our peculiar mode of apprehending it. In particular, we must be careful not to treat a past-to-future presentation of events as truer or more significant than a future-to-past presentation. We must, of course, drop the theory of evolution, or at least set alongside it a theory of anti-evolution as equally significant.

If anyone holds this view, I have no argument to bring against him. I can only say to him, "You are a teacher whose duty it is to inculcate in youthful minds a true and balanced outlook. But you teach (or without protest allow your colleagues to teach) the utterly one-sided doctrine of evolution. You teach it not as a colourless schedule of facts but as though there were something significant, perhaps even morally inspiring, in the progress from formless chaos to perfected adaptation. This is dishonest; you should also treat it from the equally significant point of view of anti-evolution and discourse on the progress from future to past. Show how from the diverse forms of life existing to-day Nature anti-evolved forms which were more and more unfitted to survive, until she reached the sublime crudity of the palæozoic forms. Show

* This ambiguity is inseparable from the operation of counting the number of particles in finite but unbounded space. It is impossible to tell whether the protons have been counted once or twice over.

how from the solar system Nature anti-evolved a chaotic nebula. Show how, in the course of progress from future to past, Nature took a universe which, with all its faults, is not such a bad effort of architecture and—in short, made a hash of it."

Entropy and Disorganisation.

Leaving aside the guidance of consciousness, we have found it possible to discover a kind of signpost for time in the physical world. The signpost is of rather a curious character, and I would scarcely venture to say that the discovery of the signpost amounts to the same thing as the discovery of an objective 'going on of time' in the universe. But at any rate it serves to discriminate past and future, whereas there is no corresponding objective distinction of left and right. The distinction is provided by a certain measurable quantity called entropy. Take an isolated system and measure its entropy S at two instants t_1 and t_2. We want to know whether t_1 is earlier or later than t_2 without employing the intuition of consciousness, which is too disreputable a witness to trust in mathematical physics. The rule is that the instant which corresponds to the greater entropy is the later. In mathematical form

dS/dt is always positive.

This is the famous second law of thermodynamics.

Entropy is a very peculiar conception, quite unlike the conceptions ordinarily employed in the classical scheme of physics. We may most conveniently describe it as the measure of disorganisation of a system. Accordingly, our signpost for time resolves itself into the law that disorganisation increases from past to future. It is one of the most curious features of the development of physics that the entropy outlook grew up quietly alongside the ordinary analytical outlook for a great many years. Until recently it always 'played second fiddle'; it was convenient for getting practical results, but it did not pretend to convey the most penetrating insight. But now it is making a bid for supremacy, and I think there is little doubt that it will ultimately drive out its rival.

There are some important points to emphasise. First, there is no other independent signpost for time; so that if we discredit or 'explain away' this property of entropy, the distinction of past and future in the physical world will disappear altogether. Secondly, the test works consistently; isolated systems in different parts of the universe agree in giving the same direction of time. Thirdly, in applying the test we must make certain that our system is strictly isolated. Evolution teaches us that more and more highly organised systems develop as time goes on; but this does not contradict the conclusion that on the whole there is a loss of organisation. It is partly a question of definition of organisation; from the evolutionary point of view it is quality rather than quantity of organisation that is noticed. But, in any case, the high organisation of these systems is obtained by draining organisation from other systems with which they come in contact. A human being as he grows from past to future becomes more and more highly organised—at least, he fondly imagines so. But if we make an isolated system of him, that is to say, if we cut off his supply of food and drink and air, he speedily attains a state which everyone would recognise as 'a state of disorganisation'.

It is possible for the disorganisation of a system to become complete. The state then reached is called thermodynamic equilibrium. The entropy can increase no further, and, since the second law of thermodynamics forbids a decrease, it remains constant. Our signpost for time disappears; and so far as that system is concerned, time ceases to go on. That does not mean that time ceases to exist; it exists and extends just as space exists and extends, but there is no longer any one-way property. It is like a one-way street on which there is never any traffic.

Let us return to our signpost. Ahead there is ever-increasing disorganisation. Although the sum total of organisation is diminishing, certain parts of the universe are exhibiting a more and more highly specialised organisation; that is the phenomenon of evolution. But ultimately this must be swallowed up in the advancing tide of chance and chaos, and the whole universe will reach a state of complete disorganisation—a uniform featureless mass in thermodynamic equilibrium. This is the end of the world. Time will *extend* on and on, presumably to infinity. But there will be no definable sense in which it can be said to *go* on. Consciousness will obviously have disappeared from the physical world before thermodynamical equilibrium is reached, and dS/dt having vanished, there will remain nothing to point out a direction in time.

The Beginning of Time.

It is more interesting to look in the opposite direction—towards the past. Following time backwards, we find more and more organisation in the world. If we are not stopped earlier, we must

come to a time when the matter and energy of the world had the maximum possible organisation. To go back further is impossible. We have come to an abrupt end of space-time—only we generally call it the 'beginning'.

I have no 'philosophical axe to grind' in this discussion. Philosophically, the notion of a beginning of the present order of Nature is repugnant to me. I am simply stating the dilemma to which our present fundamental conception of physical law leads us. I see no way round it; but whether future developments of science will find an escape I cannot predict. The dilemma is this:—Surveying our surroundings, we find them to be far from a 'fortuitous concourse of atoms'. The picture of the world, as drawn in existing physical theories, shows arrangement of the individual elements for which the odds are multillions* to 1 against an origin by chance. Some people would like to call this non-random feature of the world purpose or design; but I will call it non-committally anti-chance. We are unwilling to admit in physics that anti-chance plays any part in the reactions between the systems of billions of atoms and quanta that we study; and indeed all our experimental evidence goes to show that these are governed by the laws of chance. Accordingly, we sweep anti-chance out of the laws of physics—out of the differential equations. Naturally, therefore, it reappears in the boundary conditions, for it must be got into the scheme somewhere. By sweeping it far enough away from the sphere of our current physical problems, we fancy we have got rid of it. It is only when some of us are so misguided as to try to get back billions of years into the past that we find the sweepings all piled up like a high wall and forming a boundary—a beginning of time—which we cannot climb over.

A way out of the dilemma has been proposed which seems to have found favour with a number of scientific workers. I oppose it because I think it is untenable, not because of any desire to retain the present dilemma. I should like to find a genuine loophole. But that does not alter my conviction that the loophole that is at present being advocated is a blind alley. I must first deal with a minor criticism.

I have sometimes been taken to task for not sufficiently emphasising in my discussion of these problems that the results about entropy are a matter of probability, not of certainty. I said above that if we observe a system at two instants, the instant corresponding to the greater entropy will be the later. Strictly speaking, I ought to have said that for a smallish system the chances are, say, 10^{20} to 1, that it is the later. Some critics seem to have been shocked at my lax morality in making such a statement, when I was well aware of the 1 in 10^{20} chance of its being wrong. Let me make a confession. I have in the past twenty-five years written a good many papers and books, broadcasting a large number of statements about the physical world. I fear that for not many of these statements is the risk of error so small as 1 in 10^{20}. Except in the domain of pure mathematics, the trustworthiness of my conclusions is usually to be rated at nearer 10 to 1 than 10^{20} to 1; even that may be unduly boastful. I do not think it would be for the benefit of the world that no statement should be allowed to be made if there were a 1 in 10^{20} chance of its being untrue; conversation would languish somewhat. The only persons entitled to open their mouths would presumably be the pure mathematicians.

Fluctuations.

The loophole to which I referred depends on the occurrence of chance fluctuations. If we have a number of particles moving about at random, they will in the course of time go through every possible configuration, so that even the most orderly, the most non-chance configuration, will occur by chance if only we wait long enough. When the world has reached complete disorganisation (thermodynamic equilibrium) there is still infinite time ahead of it, and its elements will thus have opportunity to take up every possible configuration again and again. If we wait long enough, a number of atoms will, just by chance, arrange themselves in systems as they are at present arranged in this room; and, just by chance, the same sound-waves will come from one of these systems of atoms as are at present emerging from my lips; they will strike the ears of other systems of atoms, arranged just by chance to resemble you, and in the same stages of attention or somnolence. This mock Mathematical Association meeting must be repeated many times over—an infinite number of times, in fact—before t reaches $+\infty$. Do not ask me whether I expect you to believe that this will really happen.†

"Logic is logic. That's all I say."

So, after the world has reached thermodynamical equilibrium the entropy remains steady at its

* I use "multillions" as a general term for numbers of order $10^{10^{10}}$ or larger.

† I am hopeful that the doctrine of the "expanding universe" will intervene to prevent its happening.

maximum value, except that 'once in a blue moon' the absurdly small chance comes off and the entropy drops appreciably below its maximum value. When this fluctuation has died out, there will again be a very long wait for another coincidence giving another fluctuation. It will take multillions of years, but we have all infinity of time before us. There is no limit to the amount of the fluctuation, and if we wait long enough we shall come across a big fluctuation which will take the world as far from thermodynamical equilibrium as it is at the present moment. If we wait for an enormously longer time, during which this huge fluctuation is repeated untold numbers of times, there will occur a still larger fluctuation which will take the world as far from thermodynamical equilibrium as it was one second ago.

The suggestion is that we are now on the downward slope of one of these fluctuations. It has quite a pleasant subtlety. Is it chance that we happen to be running down the slope and not toiling up the slope? Not at all. So far as the physical universe is concerned, we have *defined* the direction of time as the direction from greater to less organisation, so that, on whichever side of the mountain we stand, our signpost will point downhill. In fact, on this theory, the going on of time is not a property of time in general, but is a property of the slope of the fluctuation on which we are standing. Again, although the theory postulates a universe involving an extremely improbable coincidence, it provides an infinite time during which the most improbable coincidence might occur. Nevertheless, I feel sure that the argument is fallacious.

If we put a kettle of water on the fire there is a chance that the water will freeze. If mankind goes on putting kettles on the fire until $t=\infty$, the chance will one day come off and the individual concerned will be somewhat surprised to find a lump of ice in his kettle. But it will not happen to *me*. Even if to-morrow the phenomenon occurs before my eyes, I shall not explain it this way. I would much sooner believe in interference by a demon than in a coincidence of that kind coming off; and in doing so I shall be acting as a rational scientist. The reason why I do not at present believe that devils interfere with my cooking arrangements and other business, is because I have become convinced by experience that Nature obeys certain uniformities which we call laws. I am convinced because these laws have been tested over and over again. But it is possible that every single observation from the beginning of science which has been used as a test, has just happened to fit in with the law by a chance coincidence. It would be an improbable coincidence, but I think not quite so improbable as the coincidence involved in my kettle of water freezing. So if the event happens and I can think of no other explanation, I shall have to choose between two highly improbable coincidences: (*a*) that there are no laws of Nature and that the apparent uniformities so far observed are merely coincidences; (*b*) that the event is entirely in accordance with the accepted laws of Nature, but that an improbable coincidence has happened. I choose the former because mathematical calculation indicates that it is the less improbable. I reckon a sufficiently improbable coincidence as something much more disastrous than a violation of the laws of Nature; because my whole reason for accepting the laws of Nature rests on the assumption that improbable coincidences do not happen—at least, that they do not happen in my experience.*

Similarly, if logic predicts that a mock meeting of the Mathematical Association will occur just by a fortuitous arrangement of atoms before $t=\infty$, I reply that I cannot possibly accept that as being the explanation of a meeting of the Mathematical Association in $t=1931$. We must be a little careful over this, because there is a trap for the unwary. The year 1931 is not an absolutely random date between $t=-\infty$ and $t=+\infty$. We must not argue that because for only $1/x$th of time between $t=-\infty$ and $t=\infty$ a fluctuation as great as the present one is in operation, therefore the chances are x to 1 against such a fluctuation occurring in the year 1931. For the purposes of the present discussion, the important characteristic of the year 1931 is that it belongs to a period during which there exist in the universe beings capable of speculating about the universe and its fluctuations. Now I think it is clear that such creatures could not exist in a universe in thermodynamical equilibrium. A considerable degree of deviation is required to permit of living beings. Therefore it is perfectly fair for supporters of this suggestion to wipe out of account all those multillions of years during which the fluctuations are less than the minimum required to permit of the development and existence of mathematical physicists. That greatly diminishes x, but the odds are still overpowering. The *crude* assertion would be that (unless we admit something which is not chance in the architecture of the universe) it is practically certain that at any assigned date the universe will be almost in the state of

* No doubt "extremely improbable" coincidences occur to all of us, but the improbability is of an utterly different order of magnitude from that concerned in the present discussion.

maximum disorganisation. The *amended* assertion is that (unless we admit something which is not chance in the architecture of the universe) it is practically certain that a universe containing mathematical physicists will at any assigned date be in the state of maximum disorganisation which is not inconsistent with the existence of such creatures. I think it is quite clear that neither the original nor the amended version applies. We are thus driven to admit anti-chance; and apparently the best thing we can do with it is to sweep it up into a heap at the beginning of time, as I have already described.

The connexion between our entropy signpost and that dynamic quality of time which we describe as 'going on' or 'becoming' leads to very difficult questions which I cannot discuss here. The puzzle is that the signpost seems so utterly different from the thing of which it is supposed to be the sign. The one thing on which I have to insist is that, apart from consciousness, the increase of entropy is the only trace that we can find of a one-way direction of time. I was once asked a ribald question: How does an electron (which has not the resource of consciousness) remember which way time is going? Why should it not inadvertently turn round and, so to speak, face time the other way? Does it have to calculate which way entropy is increasing in order to keep itself straight? I am inclined to think that an electron does do something of that sort. For an electric charge to face the opposite way in time is the same thing as to change the sign of the charge. So if an electron mistook the way time was going it would turn into a positive charge. Now, it has been one of the troubles of Dr. P. A. M. Dirac that in the mathematical calculations based on his wave equation the electrons do sometimes forget themselves in this way. As he puts it, there is a finite chance of the charge changing sign after an encounter. You must understand that they only do this in the mathematical problems, not in real life. It seems to me there is good reason for this. A mathematical problem deals with, say, four electric charges at the most; that is about as many as a calculator would care to take on. Accordingly, the unfortunate electron in the problem has to make out the direction of past to future by watching the organisation of three other charges. Naturally, it is deceived sometimes by chance coincidences which may easily happen when there are only three particles concerned; and so it has a good chance of facing the wrong way and becoming a positive charge. But in any real experiment we work with apparatus containing billions of particles—ample to give the electron its bearings with certainty. Dirac's theory predicts things which never happen, simply because it is applied to problems which never occur in Nature. When it is applied to four particles alone in the universe, the analysis very properly brings out the fact that in such a system there could be no steady one-way direction of time, and vagaries would occur which are guarded against in our actual universe consisting of about 10^{79} particles.

Heisenberg's Principle.

A discussion of the properties of time would be incomplete without a reference to the principle of indeterminacy, which was formulated by Heisenberg in 1927 and has been generally accepted. It had already been realised that theoretical physics was drifting away from a deterministic basis; Heisenberg's principle delivered the knock-out blow, for it actually postulated a certain measure of indeterminacy or unpredictability of the future as a fundamental law of the universe. This change of view seems to make the progress of time a much more genuine thing than it used to be in classical physics. Each passing moment brings into the world something new—something which is not merely a mathematical extrapolation of what was already there.

The deterministic view which held sway for at least two centuries was that if we had complete data as to the state of the whole universe during, say, the first minute of the year 1600, it would be merely a mathematical exercise to deduce everything that has happened or will happen at any date in the future or past. The future would be determined by the present as the solution of a differential equation is determined by the boundary conditions. To understand the new view, it is necessary to realise that there is a risk of begging the question when we use the phrase 'complete data'. All our knowledge of the physical world is inferential. I have no direct acquaintance with my pen as an object in the physical world; I infer its existence and properties from the light waves which fall on my eyes, the pressure waves which travel up my muscles, and so on.

Precisely the same scheme of inference leads us to infer the existence of things in the past. Just as I infer a physical object, namely, my pen, as the cause of certain visual sensations now, so I may infer an infection some days ago as the cause of an attack of measles. If we follow out this principle completely we shall infer causes in the year 1600

for all the events which we know to have happened in 1930. At first sight it would seem that these inferred causes have just as much status in the physical world as my fountain pen, which is likewise an inferred cause. So the determinist thinks he has me in a cleft stick. If the scientific worker poking about in the universe in 1600 comes across these causes, then he has all the data for making a correct prediction for 1930; if he does not, then he clearly has not complete knowledge of the universe in 1600, for these causes have as much right to the status of physical entities as any of our other inferences.

I need scarcely stop to show how this begs the question by arbitrarily prescribing what we should deem to be complete knowledge of the universe in 1600, irrespective of whether there is any conceivable way in which this knowledge could be obtained at the time. What Heisenberg discovered was that (at least in a wide range of phenomena embracing the whole of atomic physics and electron theory) there is a provision of Nature that just half of the data demanded by our determinist friend might with sufficient diligence be collected by the investigators in 1600, and that complete knowledge of this half would automatically exclude all knowledge of the other half. It is an odd arrangement, because you can take your choice which half you will find out; you can know either half but not both halves. Or you can make a compromise and know both halves imperfectly, that is, with some margin of uncertainty. But the rule is definite. The data are linked in pairs and the more accurately you measure one member of the pair the less accurately you can measure the other member.

Both halves are necessary for a complete prediction of the future, although, of course, by judiciously choosing the type of event we predict we can often make safe prophecies. For example, the principle of indeterminacy will obviously not interfere with my prediction that during the coming year zero will turn up approximately $\frac{1}{37}$ of the total number of times the roulette ball is spun at Monte Carlo. All our successful predictions in physics and astronomy are on examination found to depend on this device of eliminating the inherent uncertainty of the future by averaging.

As an illustration, let us consider the simplest type of prediction. Suppose we have a particle, say an electron, moving undisturbed with uniform velocity. If we know its position now and its velocity, it is a simple matter to predict its position at some particular future instant. Heisenberg's principle asserts that the position and velocity are paired data; that is to say, although there is no limit to the accuracy with which we might get to know the position and no limit to the accuracy with which we might get to know the velocity, we cannot get to know both. So our attempt at an accurate prediction of the future position of the particle is frustrated. We can, if we like, observe the position now and the position at the future instant with the utmost accuracy (since these are not paired data) and then calculate what has been the velocity in the meantime. Suppose that we use this velocity together with the original position to compute the second position. Our result will be quite correct, and we shall be true prophets—after the event.

This principle is so fully incorporated into modern physics that in wave mechanics the electron is actually pictured in a way which exhibits this 'interference' of position and velocity. To attribute to it exact position and velocity simultaneously would be inconsistent with the picture. Thus, according to our present outlook, the absence of one half of the data of prediction is not to be counted as ignorance; the data are lacking because they do not come into the world until it is too late to make the prediction. They come into existence when the event is accomplished.

I suppose that to justify my title I ought to conclude with a prophecy as to what the end of the world will be like. I confess I am not very keen on the task. I half thought of taking refuge in the excuse that, having just explained that the future is unpredictable, I ought not to be expected to predict it. But I am afraid that someone would point out that the excuse is a thin one, because all that is required is a computation of averages and that type of prediction is not forbidden by the principle of indeterminacy. It used to be thought that in the end all the matter of the universe would collect into one rather dense ball at uniform temperature; but the doctrine of spherical space, and more especially the recent results as to the expansion of the universe, have changed that. There are one or two unsettled points which prevent a definite conclusion, so I will content myself with stating one of several possibilities. It is widely thought that matter slowly changes into radiation. If so, it would seem that the universe will ultimately become a ball of radiation growing ever larger, the radiation becoming thinner and passing into longer and longer wavelengths. About every 1500 million years it will double its radius, and its size will go on expanding in this way in geometrical progression for ever.

Science and Prediction.

"PROPHECY", we are told, "is the most gratuitous of all forms of error", and long-distance forecasts have a way of going wrong, even when apparently firmly based upon all the available knowledge of the time. Thus, Sir William Crookes predicted a world shortage of wheat for the present age, when in fact (owing to the unexpected success of science in fixing atmospheric nitrogen and making new fertilisers) there is an embarrassing surplus. The real justification for making such forecasts is not that they are likely to be realised; but that they throw light upon the state of contemporary science, and may indicate where it requires supplementing. This may be exemplified from the address of Sir Arthur Eddington presented in the present supplement.

Before analysing Sir Arthur's basis of predictions concerning the end of the world, we may briefly consider earlier discussions of this topic. At one time, such speculations had a theological basis, and often predicted a very unequal distribution of temperature, which in some regions would be excessively high. In the nineteenth century, these were replaced by considerations concerning the loss of heat by the earth and the sun. The earth was apparently cooling so rapidly as to leave insufficient time for biological evolution, and in a comparatively short time (from the evolutionary point of view) both earth and sun seemed doomed to experience a temperature which would be uniform and excessively low. However, the date of this predicted catastrophe had to be put forward about a billion and a half years when radioactivity was discovered, for it revealed immense quantities of stored-up atomic energy which could be changed into heat. Another postponement was necessitated by the discovery of the convertibility of mass and radiation. This gave the sun an enormously increased lifetime. A period at least a hundred times more remote than before was offered by the astronomer's suggestion that in the interior of heavy atoms an electron may combine with a proton and release energy by their mutual annihilation. But all this merely put off the evil day when a dying earth should at last fall into a dying sun and the whole universe, ever contracting, finally collapse in a single heap. Sir Arthur Eddington, taking as his basis the second law of thermodynamics and recent developments of the cosmological theory of relativity, adopts the prediction as to the ultimate uniformity and lowness of temperature, but declares the universe to be expanding instead of contracting. Possibly it will become a ball of radiation which doubles its size every 1500 million years, growing ever more and more attenuated.

Let us consider the evidence for the physical laws underlying these predictions. The cosmological theory of relativity may be considered as having arisen from the attempt to make the boundary conditions, as well as the differential equations expressing physical laws, independent of the choice of co-ordinates. Einstein in 1917 accomplished this by the drastic method of abolishing the boundary, and postulating a universe which was finite though unbounded (the analogue of the finite but unbounded surface of a sphere). An alternative theory was given by de Sitter; but, as was pointed out by Sir Arthur Eddington, neither of these theories could be accepted as corresponding to physical realities. One contained matter but no motion, and the other motion but no matter. No further progress was made for about ten years, when Lemaître obtained a new solution of the relativity equations. This corresponded to an expanding universe, and it was afterwards shown that Einstein's and de Sitter's theories were limiting cases of this, one at the beginning of the motion and the other at the end, probably both unattainable. The strong point of Lemaître's theory is that it offers an explanation of the observed redness of the spectra of many nebulæ, which is generally taken to mean that they are moving away from us at enormous speeds. But it must not be forgotten that other explanations of this redness are possible. Lemaître's cosmological theory holds the field for the present, but it is far from being thoroughly tested.

The second law of thermodynamics is on a different footing. Nothing seems better established than that it is impossible for a self-acting system, unaided by an external agency, to convey heat from one body to another at a higher temperature. Yet even here doubt may be felt as to whether this is without exception. Millikan tells us that the intensely cold regions in the depths of interstellar space are the source of a very penetrating radiation, known as the cosmic rays. These seem to be due to the building up of the more complex elements out of hydrogen. In other words, the processes of disintegration and decay which are taking place elsewhere appear to be reversed here. Let us not be too sure that the universe is like a watch that is always running down; there may be a rewinding. The process of creation may not yet be finished.

H. T. H. PIAGGIO.

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hills, Lanarkshire, in 1763. Given a good education, he became a student in Black's classes at the University of Edinburgh; but following in his father's footsteps, he entered the service of the Wanlockhead Mining Company near Leadhills. Familiar with the steam engines of Newcomen and Watt, in 1786 he made a model steam carriage and in 1787 took out a patent for a new form of steam engine. Through this he was brought into contact with Patrick Miller, the banker, who was desirous of trying a steam engine in one of the double-hulled boats with which he was experimenting. To meet Miller's wishes, Symington constructed an engine with cylinders 4 in. in diameter, which in October 1788 drove one of Miller's boats across the little Dalswinton Loch in Dumfriesshire at 4-5 miles an hour. Next year a larger boat and a larger engine were experimented with, but the results were not very satisfactory and the matter was not pursued further. The engine of 1788 happily was preserved and can be seen in the Science Museum, South Kensington. It is the oldest marine engine in existence, and there are few older steam engines of any kind.

The experiments of Miller and Symington had been preceded by those of Rumsey on the Potomac and of Fitch on the Delaware, and Fitch was the first in the world to form a steam boat company and to carry passengers. His company, it is true, had but a short life, but from then onwards to the end of the eighteenth century there was probably never a time when one or other of the steam boat pioneers was not at work. Symington's second opportunity came in 1801, when Thomas, Lord Dundas of Kerse, a governor of the Forth and Clyde Canal Company, instructed him to build a steam boat for use on the Canal. The hull was constructed by Hart, of Grangemouth, and the *Charlotte Dundas*, as the boat was called, was 56 ft. long and 18 ft. wide. There was a recess in the stern for a paddle wheel, the boiler was placed aft on the starboard side, and the engine on the port side. To the uninitiated, the engine of 1788 might appear to have required more ingenuity to design than that of 1801. It is certainly far more complicated, but this was partly due to the steps Symington had to take to avoid the ramifications of Watt's patents which were in force. In 1801 those patents had expired, and, free to use the ideas of his predecessors and to combine these in any way he thought best, Symington was able to construct an engine for the *Charlotte Dundas* which would almost meet modern requirements. The engine was double-acting with one cylinder, and the piston rod drove the crank shaft of the paddle wheel direct through a crosshead and a connecting rod. The air pump and condenser were placed below the cylinder, the former being worked by a bell-crank lever.

The running of the *Charlotte Dundas* quickly proved that Symington had produced a reliable and powerful engine, and the capacity of the boat was shown by her successfully towing two vessels of 70 tons each a distance of 19½ miles. Convinced of the utility of the boat, Lord Dundas introduced Symington to the Duke of Bridgewater, who without much hesitation decided to adopt vessels similar to the *Charlotte Dundas* for the Bridgewater Canal and ordered the construction of eight steam boats. Had the Duke lived but another year, there is little doubt that the boats would have been built and that to-day we should date the birth of steam navigation from the *Charlotte Dundas* and not from the *Clermont* and the *Comet*. The Duke's death in 1803, however, led to the cancellation of the order; and about the same time the owners of the Forth and Clyde Canal, afraid of the effects of the wash caused by the *Charlotte Dundas*, laid her up on the mud near Bainsford Drawbridge, which became her grave. She was never used again, and engine and hull alike have long since been destroyed.

This proved the turning-point in Symington's career and he never recovered from the disastrous set-back to his fortunes. When more than sixty years of age, he sought assistance from the Government and was granted two small sums, of £100 and £50. His death took place in London on Mar. 22, 1831, and three days later he was buried in the churchyard of St. Botolph, Aldgate. His grave never bore a stone, but in 1903 a tablet to his memory was placed in the church by the late Lord Bearsted, who was then Sir Marcus Samuel and Lord Mayor of London. A marble bust of Symington was unveiled in the Royal Scottish Museum in 1890 by Lord Kelvin.

Though in his day neglected, Symington to-day is recognised as the designer of the first practical steam boat, and at the request of the Institute of Marine Engineers and the Newcomen Society, the vicar of St. Botolph, Aldgate, has arranged to hold a special service to commemorate the centenary of his death. This service will take place at 11 A.M. on Sunday, Mar. 22, the hundredth anniversary of Symington's death, and an address on Symington's work will be given by Engineer Vice-Admiral Sir Robert Dixon.

Obituary.

MR. H. HARRIES.

WITH the death of Mr. Henry Harries on Feb. 8, at the age of seventy-nine years, we lose one of the older generation of meteorologists. Born on Jan. 20, 1852, he entered the Marine Division of the Meteorological Office in 1875. In 1903 he was transferred to the Forecast Division, where he took regular duty as a forecaster. In 1919 he returned to the Marine Division, where he held the post of assistant superintendent until his retirement in March 1920.

Mr. Harries' interest in meteorological matters extended beyond his official duties, however, especially along a number of curious bypaths of knowledge. He was convinced that explosions in collieries were connected with high barometric

pressure and supported his thesis in a long letter to NATURE in 1887 (vol. 36, p. 437). He also developed the theory that some of the barometric depressions which visit the British Isles originate in tropical cyclones, and he actually succeeded in tracing the course of one such storm from the Philippines to Scandinavia, more than half-way round the globe—no easy matter in 1882.

The capacity for painstaking research which characterised this paper also marked Mr. Harries' collection of occurrences of hail and thunder storms in Arctic regions, his study of the frequency, size, and distribution of hail at sea, and his paper on the great storm of November 1703, in which he brought to light some long-buried official records. The same thoroughness, in a different direction, was shown in his paper on "The Eddy Winds of Gibraltar", in which he displayed great ingenuity in the use of simple methods of aerological investigation. This paper was published in 1914 by the Royal Meteorological Society, of which he was a fellow from 1887 until 1914.

DR. FLORENCE BUCHANAN.

BY the death of Dr. Florence Buchanan on Mar. 13, a familiar figure is removed from the laboratories at Oxford. For the past ten years she had been handicapped by increasing blindness; but even so, occasional articles have appeared from her pen. Previously she had carried out many interesting studies in the fields of zoology and physiology. Her earliest papers, on the respiratory organs of decapods and on annelids, appeared in the *Quarterly Journal of Microscopical Science* while she was still a student at University College, London, and there the influence of Sir Ray Lankester turned her attention to zoological studies, particularly of the polychæts. Later, with Sir John Burdon Sanderson at Oxford, she turned to physiological experiments upon the electrical response of muscle, recorded photographically by a capillary electrometer, and as a result of her investigations she was awarded several prizes, received the degree of D.Sc. from the University of London, and was made a fellow of University College.

Throughout her physiological work, Dr. Buchanan retained her first interest in animal life, and to a biologist some of her most striking researches were concerned with the frequency of the heart-beat in small mammals and birds, with the varying rates of heart-beat in hibernating and waking mammals, and with the general problem of hibernation. Heredity may have accounted for Dr. Buchanan's scientific skill and enthusiasm, for she was a daughter of the late Sir George Buchanan, chief medical officer of the Local Government Board, and a sister of Sir George Seaton Buchanan and Lady Adam Smith, wife of the principal of the University of Aberdeen. J. R.

THE death occurred on Sunday, Feb. 15, of W. G. Robson, lecturer in natural philosophy in the United College of the University of St. Andrews. From 1892, when Mr. Robson was appointed assistant to Prof. A. S. Butler, he was almost continuously associated with the University either in St. Andrews or Dundee. During the War he was engaged in the Aircraft Instruments Department in London, and had charge of the Oxygen Research Laboratory. His wide experience, kindly disposition, and his knowledge of mathematics, physics, and electrical engineering made him a most valuable member of the University staff.

WE regret to announce the following deaths:

Dr. M. W. Beijerinck, founder and director of the Microbiological Institute at Delft, on Jan. 1, aged seventy-nine years.

Prof. G. Gehlhoff, of the Technical Highschool, Berlin, president of the Deutsche Gesellschaft für Technische Physik, vice-president of the Deutsche Glastechnische Gesellschaft and a director of the Osram G.m.b.H., who in recent years took a leading part in the development of glass technology in Germany and made a number of notable contributions from his own laboratory, died on Mar. 12.

Prof. D. Hepburn, C.M.G., professor of anatomy in the Cardiff Medical School of the University of Wales, formerly president of the Anatomical Society of Great Britain and Ireland, on Mar. 10, aged seventy-two years.

Prof. Carl Emil Hansen Ostenfeld, professor of botany and director of the botanical garden in the University of Copenhagen, on Jan. 16, aged fifty-eight years.

Prof. Enrico Sereni, head of the department of physiology in the Stazione Zoologica, Naples, on Mar. 1, aged thirty-one years.

Prof. Otto Wallach, emeritus professor of chemistry in the University of Bonn, who specialised in the chemistry and industrial uses of the terpenes and was awarded the Nobel prize for chemistry in 1910, on Mar. 1, aged eighty-four years.

News and Views.

THE Council of the Royal Society has agreed to recommend for election as fellows of the Society the following seventeen candidates: Percy George Hamnall Boswell, professor of geology in the Imperial College of Science and Technology; Alfred Joseph Clark, professor of pharmacology in the University of Edinburgh; Charles Davidson, assistant at the Royal Observatory, Greenwich; Reginald Ruggles Gates, professor of botany, King's College, London; Charles Stanley Gibson, professor of chemistry, Guy's Hospital Medical School; Hermann Glauert, Principal Scientific Officer, Royal Aircraft Establishment, Farnborough; Charles Robert Harington, reader in pathological chemistry in the University of London (University College Hospital Medical School); Isidor Morris Heilbron, professor of organic chemistry in the University of Liverpool; Sir Alexander Cruikshank Houston, Director of Water Examinations to the Metropolitan Water Board; Lieut.-Col. Sydney Price James, I.M.S., adviser on tropical diseases to the Ministry of Health; Charles Frewen Jenkin, lately professor of engineering science in the University of

Oxford; Stanley Wells Kemp, director of research, *Discovery* Expedition; Thomas Howell Laby, professor of natural philosophy, University of Melbourne; William Kingdon Spencer, palæontologist; Edward Charles Titchmarsh, professor of pure mathematics in the University of Liverpool; Wilfred Trotter, surgeon to University College Hospital; Miles Walker, professor of electrical engineering, University of Manchester.

THE Dalton medal of the Manchester Literary and Philosophical Society, which was awarded to Sir J. J. Thomson on Mar. 10 on the occasion of his visit to Manchester, was founded so far back as the year 1864, but, curiously enough, no allotment was made until 1898. The circumstances attending its early institution and production are somewhat obscure; at any rate it was a medallic gift to be adopted "for presentation on such occasions as the society may determine", a decision which left future bestowal an open matter, a point well seen in the awards, which have only occurred as follows: Dr. Schunck (1898), Sir Henry Roscoe (1900), Prof. Osborne Reynolds (1903), Lord Rutherford (1919), Sir J. J. Thomson (1931). The medal is struck in bronze; the obverse bears the head of John Dalton, and on the reverse, within crossed laurel branches, is a sphinx, with accompanying legend, "Knowledge is Power". The first presentation of what was apparently an original Dalton medal was made on Mar. 29, 1898, to Dr. Edward Schunck, in "recognition of his series of researches on the natural colouring matters, with which he has enriched chemistry". Schunck had been a member of the Manchester Literary and Philosophical Society for fifty-six years. It may be recalled that on the occasion of the gift, Sir Joseph Hooker attended to receive the Wilde gold medal, whilst Sir Michael Foster delivered the Wilde lecture, with the title "On the Physical Basis of Psychical Events".

THE discontinuance of a medallic gift by a scientific society is unusual. This has been the case, however, with the Wilde gold medal of the Manchester Literary and Philosophical Society. In 1895, Dr. Henry Wilde, a generous benefactor in many directions, established a fund, part of which was to be devoted to the annual award of a gold medal for distinguished services to science and philosophy. The first medal was given in 1896 to Sir George Stokes for "pre-eminent services to mathematical and physical science". Sir George visited Manchester in the following year, received the medal, and gave an address entitled "The Nature of the Röntgen Rays". The final gift of the kind was made in 1908 to Sir Joseph Larmor. Referring to the article on the sesqui-centenary of the foundation of the Manchester Literary and Philosophical Society in NATURE of Mar. 14 (p. 408), it has been pointed out by a correspondent that the Copley medal of the Royal Society was never awarded to John Dalton. Dalton received the Royal Society's Royal medal in 1826, the first presented at the time of institution.

THE election on Mar. 9 of Prof. Elie Cartan to the seat of the late Paul Appell in the Paris Academy of Sciences has added a prominent mathematician to the distinguished body of men of science of the Quai Conti. Prof. Cartan has specialised in the theory of groups and in higher geometry, and has developed these fundamental branches of mathematics in unexpected and far-reaching directions. We still remember the deep impression he made at the International Congress of Mathematicians in Bologna, when he showed how to determine a complete orthogonal system of functions in any Riemannian space with a positive curvature and symmetrical with reference to each of its points; and how to derive a geometrical representation of these series of fundamental functions by means of a special type of isometrical transformations. Indeed, in his numerous memoirs on these abstruse topics, Prof. Cartan has given a remarkable generalisation to the Riemannian spaces, thus preparing the way to subsequent developments in natural philosophy.

IN Newtonian mechanics, as is well known, gravitation has no influence on measurements as such. In Einstein's universe, however, all measurements follow so closely the structural character of the gravitational field in which they are immersed, that a knowledge of the geometry of that field is equivalent to a knowledge of its physical properties; so that mechanics is implied in geometry again, as was the case during the golden period of Greek science. It appears necessary, then, to labour in detail the manifold interpretation of the notion of space underlying the geometrical and physical description of the universe. The curved space discovered by Riemann in 1853, which found its practical application in 1916, has to be itself generalised and enlarged if the future claims of theoretical physics have to be satisfied. In this connexion 'Cartan's spaces', by reason of their greater generality and completeness, are of supreme importance. This was a new revelation to some of us who listened to his illuminating exposition at the International Congress of Philosophy at Naples in 1924, when Prof. Cartan spoke of the torsional properties of space and the difficulties created by magnetic phenomena in the single vectorial representation of material particles. The practical value of his intuitions has been confirmed since by the implications of De Broglie's wave-mechanics, which seems to demand a more complex theory of groups for its geometrical interpretation. As a mathematician, Prof. Cartan has had a distinguished career. Born in 1869, he studied at the École Normale Supérieure of Paris, and took his doctor's degree in 1894. He now occupies the chair of higher geometry, which was held previously by Darboux, at the University of Paris. His numerous mathematical memoirs earned for him, last autumn, the Grand Prix of £400 of the Paris Academy of Sciences.

AFTER a keen debate in the House of Commons, on Mar. 16, Clause 4 of the Representation of the People Bill, which had been before the House in committee, was defeated by 246 votes to 242. The special claim of Queen's University, Belfast, was first brought forward by Mr. Ross and supported by Col. Sinclair, pro-chancellor of Queen's University and its representative in Parliament. This claim, however,

was rejected by 178 votes to 168. The motion for the deletion of Clause 4 from the Bill was presented by Lord Hugh Cecil. He analysed the question of equalitarian democracy, which is based on the 'one vote, one value' theory, and declared it does not and cannot exist. He then appealed to the members not to spoil the tradition of true representation. Major Church opposed his own party by strongly supporting this appeal. He considers it intolerable that this bill should suggest that university education is not of special value, especially in view of the fact that the universities are no longer class preserves and produce advisers to governments and leaders of science and industry. Mr. Clynes refused the appeal for a free vote, pointing out that, at least, there is no justification for giving university voters twice the representation of other voters. He pointed out that university members have shown little special political capacity. The Government was also supported by Sir Herbert Samuel.

IN a pamphlet entitled "A National Policy" (London: Macmillan and Co., Ltd. 6*d*.), describing the programme advanced by Sir Oswald Mosley, M.P., there are some references to scientific research which, without trenching on questions of party politics, it may be of interest to summarise. No task, it is argued, is of more vital importance than that of mobilising our great scientific resources and attainments. Great Britain's industrial future depends on the rapid and effective adoption of new scientific results more than upon any other single factor. Our high degree of industrialisation, our unrivalled technical experience, the skill of our workers, our great resources of scientific ability and devotion, give us the opportunity to maintain our lead indefinitely. What is chiefly lacking is the effective co-ordination and application of our resources. The work of the Department of Scientific and Industrial Research is commended; but it is said that the scale on which it is allowed to operate is too limited. A method must be adopted by which new devices and inventions can be carried through the difficult intermediate stage between successful laboratory results and commercial exploitation. At present, the Department can only test inventions at the owner's expense and issue a report on the results. A certain maximum sum should be set aside each year for the Department's use for the development of a small number of selected inventions, which, after making a suitable financial arrangement with the patentee, should be taken right out of the laboratory stage and put on the market under public auspices.

SIR OSWALD MOSLEY also suggests the fostering of inventions and the extension of agricultural and medical research, while an organised attempt might be made to standardise many of the basic products of industry for mass production purposes, comparable to Mr. Hoover's remarkable campaign in the United States of America. The establishment of new industries under the direction of a National Investment Board is advocated where these industries might be of great value to the community though as yet they are not in a position to attract private enterprise. Thus, coal carbonisation appears to be insufficiently profitable to attract an adequate amount of private capital, but its establishment, it is suggested, might be justified on grounds of public policy, because (1) it might mean the 'salvaging' of a large amount of the community's capital which has been sunk in coal mining and would be rendered profitable again if a new market for coal were created, (2) it would lessen our dependence on imported oil fuel, (3) a smokeless fuel would be produced, and (4) the new work available in the coal-fields would mean a saving in unemployment relief.

THE Council of the Linnean Society of London has reached an important decision with regard to the publication of the *Proceedings* of the Society. The *Proceedings*, instead of being published in an annual volume, are being issued sheet by sheet of 16 pages, and in this way an abstract of a paper read before the Society may be in the hands of fellows and of the public between three and eight weeks after the reading of the paper. Each sheet of the *Proceedings* so issued will rank as a publication on the date of issue, so that the utmost is being done to conserve for contributors to the Society the priority of their discoveries, provided, of course, that in the case of new species a sufficient diagnosis accompanies the publication of the new name. This precaution has not been taken, for example, in the case of a new species of *Hoplophorus* described in a recent issue, so that the advantage of early publication is lost in this case. The importance in time of the arrangement which has now come into force is well illustrated by the first sheet of the new issue. The *Proceedings* of Nov. 20, 1930, were issued on Dec. 17, whereas the annual volume issued in January 1931 contains reports of 'proceedings' so far back as Nov. 7, 1929. Arrangements have been made whereby fellows, foreign members, and associates who still wish to possess the complete *Proceedings* in book form may obtain a copy each year at half the published price.

THE Belfast Naturalists' Field Club, for some time past, has had under consideration the advisability of making a survey of the antiquities of that part of Northern Ireland covered by it and its affiliated societies. Both the number and character of these antiquities and the risks to which the better known are exposed in modern conditions have been judged to make the matter one of such importance that the authorities of the Field Club have appointed a special committee to deal with it. Members and others have been asked to co-operate with the Committee by sending in lists, with full particulars, of any antiquities in their neighbourhood, especially those which are not included in the Ordnance maps. Plans, sketches, and photographs are to be included, with a statement of exact position. The topographical and full bibliographical details will be indexed and made available for consultation by students. The scheme will cover buildings, monuments, and other remains of both historic and prehistoric times. The chairman of the Committee is Mr. H. Albert Campbell, and the honorary secretary, Miss M. Gaffikin.

THE course of popular lectures on the native races of the British Empire given under the auspices of the Royal Anthropological Institute came to an end for the current session on Mar. 11 with Mr. E. Torday's lecture on "The Things that Matter to the African". Mr. Torday's lecture was a subtle but most illuminating interpretation of native life and tradition in West Africa, in which he showed that the frivolous, light-hearted individual of many travellers is far from being the real man. In fact, he appears to be something of an opportunist; for, while bowing to the domination of the sultanates, he has, at heart and in actual practice, remained a thorough democrat, in accordance with his long-established tradition. The case was well argued and convincingly supported by a wealth of detailed evidence which covered both religious belief and social custom. Full justice was done to the remarkable but too little known character and influence of the women. Mr. Torday's conclusion that the West African is capable of concerted and persevering action when he aims at social ideals, taken with what he said in the body of his lecture, is both a warning and a guide to our administrators. For it would appear that under the impact of European influences, a new culture is shaping which will differ from that of the past, but in which our share will depend very much upon our sympathetic understanding of native tradition. We trust that Mr. Torday's lecture will be given permanent form, for it is, without question, one of the most important pronouncements on the West Africans which has been made in recent years.

INTERNATIONAL telephony has made wonderful progress during the past year. At the beginning of 1929 radio telephony provided daily telephone service to more than twenty-six countries. In 1930 the total of international connexions wholly or partly effected through radio telephony was increased to 177. The most important groups of connexions can be divided into three classes, the first one linking North and South America. This group connects the United States, Canada, Cuba, and Mexico on one side with the Argentine, Chile, and Uruguay on the other. The second group involves three new channels between Europe and South America. They operate from Paris, Berlin, and London to Buenos Aires. Land line connexions bring a total of twenty other countries into these circuits. The third group involves the London-Sydney circuit—a distance of 9192 miles. These circuits connect most of the telephone users of the United States, Canada, Mexico, Great Britain, Hungary, and Italy with Australia. Many more lines are being constructed, including one connecting the United States and Australia directly. Spectacular conversations have been held from an aeroplane over the city of Buenos Aires with points in the United States, with the s.s. *Majestic* on the high seas, and with Sydney, Australia, a distance of 14,000 miles. A conversation has also been transmitted round the world from Schenectady and then broadcast. According to *Electrical Communication* for January, the international telephone directory (A.T.1) for 1929 contained about 12,000 entries from 1485 towns in 27 different countries; the 1930 edition contains more than 50,000 entries from 2718 towns in 38 countries.

THE tenth annual report of the Electricity Commissioners, which has just been published, shows clearly that the electric supply industry in Great Britain has been little if at all affected by the almost universal trade depression. Dividing the country into regional districts of supply, linking up all the efficient large power stations, and gradually eliminating where possible the less efficient stations, is leading to a better utilisation of our coal resources. The total number of units generated in the year ending in March 1921 was 5167 million units and the fuel consumption was 7·356 million tons. For the year which ended in March 1930, the total number of units generated was 11,961 million, with a fuel consumption of 10·141 million tons. It will be seen that although the number of units generated has been doubled, the consumption of coal has only increased by about 50 per cent. Last year was noteworthy because of the continued expansion of the supply and the many schemes that are being put in hand for the improvement and further extension of public supplies. The steady growth of the domestic supply has had a stabilising effect on the industry. The units generated last year show an increase of 10 per cent of the number generated in the preceding year. A number of small stations have been erected in isolated districts. On the estimated population of Great Britain (44·5 millions) the sales of electrical units represent 193 units per capita, as compared with 171 in the previous report. The question of rural development is discussed and it is pointed out that the prospects are favourable in certain cases.

THE prize for 1930 for an improvement in the science or practice of navigation offered by the Royal Society of Arts, under the terms of the Thomas Gray Memorial Trust, has been awarded to Messrs. Charles A. Stevenson and David Alan Stevenson, of Edinburgh, for their invention of the talking beacon installed at Cumbrae Lighthouse. The beacon, to which reference was made in NATURE of Jan. 24, p. 138, consists of an ingenious combination of fog signal and wireless transmitter. The fog signal consists of three blasts followed by a short silence and then two further blasts. At the same time, on a wireless receiver, a listener hears (*a*) the name of the beacon in speech (Cumbrae), (*b*) the three blasts of the fog signal, (*c*) counting in speech, in cables and sea miles up to five miles, and (*d*) the two blasts of the fog signal. This is followed by a silent interval lasting twenty-seven seconds and is then repeated. Immediately before each mile is spoken a bell is sounded. The distance which the observer hears in his receiver, coinciding with the end of the third blast heard through the air, gives him the distance of his ship from the lighthouse. The spoken words in the signal come from a gramophone record on a turn-table, which is engaged and disengaged by means of a clutch with another turn-table kept constantly revolving by air turbine or motor. The Council of the Royal Society of Arts is offering this year another prize of £100 to any

person who may bring to its notice a valuable improvement in the science or practice of navigation proposed or invented by himself in the years 1930 and 1931, and a prize of £100 for an essay on "The Stability of Ships, with special reference to the particulars which should be supplied by Shipbuilders, and also the value of any mechanical devices for ascertaining the M.G., with which you are acquainted". Claims and essays must reach the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.2, not later than Dec. 31, 1931.

AT a conference at the Birmingham section of the British Industries Fair, Dr. C. H. Lander, Director of Fuel Research, discussed the "Gas Industry in relation to British Fuel Problems". He stressed the importance of its contribution to the smoke problem, as a purveyor of smokeless fuels, to the domestic heating problem, and to the problem of obtaining oil and petrol from coal. The carbonisation industries produce solid, liquid, and gaseous fuels and so all their problems are related and need to be considered together. The current abundance of liquid fuels should not blind us to the possible future need for deriving supplies from coal. The gas industry is well placed for marketing all the products of the carbonisation and hydrogenation of coal or its products. In view of the potential contribution of the carbonisation industries to the reduction of smoke, Dr. Lander pleaded for collaboration of the gas and coking industries in the utilisation and marketing of their products. Sir Arther Duckham contrasted the potential contribution of the gas industry to the fuel problems of Great Britain with the legislative shackles imposed on its development, the restrictions placed on the use of gas by some local authorities, arising from an imperfect grasp of fuel problems by the general public and even by our legislators.

THE first number of vol. 3 of the *Collection of Czechoslovak Chemical Communications* (Jan.-Feb. 1931) is a special issue dedicated to the memory of Prof. František Wald, who died suddenly in October of last year. His chief contributions to the advancement of science in central Europe were outlined in the obituary notice which appeared in NATURE for Jan. 10, p. 64. Had he lived, Prof. Wald would have attained seventy years of age last January, and the original intention of the editors of *Collection* was that this issue should have been a jubilee number in his honour. Right up to the time of his death, Wald was engaged in elaborating his phenomenalistic theory of phases and stoichiometry. These views are embodied partly in an article by his friend Dr. A. Kříž, and partly in a hitherto unpublished article by Wald himself, entitled "Foundations of a Theory of Chemical Operations". From these, it is clear that he disregarded much of the atomic theory and his definitions of elements and compounds do not coincide with those accepted generally. His ideas attracted the attention of Prof. Wilhelm Ostwald, whose friendship he enjoyed and who included him among the "Great Men of Science". Prof. Wald was for many years chief chemist to an important metallurgical undertaking at Kladno, and among his seventy contributions to various scientific periodicals are several dealing with the adaptation of standard methods of chemical analysis to the special needs of metallurgy, especially to the evaluation of ores and the analysis of alloys. In addition to appreciative articles on Wald's life and work, this special number of the Czechoslovak *Collection* contains several other articles of outstanding merit, including an account of some iron-carbon-silicon alloys (by Drs. Kříž and Pobořil) and further polarographic studies with the dropping mercury cathode by Prof. Heyrovský and collaborators, who find that in acid solution, nitric oxide is reduced to ammonia at a potential of 0·77 volt from that of the normal calomel electrode.

WE have received a copy of the Subject Index to volumes 1 to 60 of the *Journal of Physiology*, which has been prepared by Dr. J. G. Priestley, of Oxford. The Physiological Society recently published a history of its first fifty years, written by Sir Edward Sharpey Schafer, and an author index to the first sixty volumes has also been issued. These three volumes cover an important period in the history of physiology, a period which has seen its development into the science of to-day. An important part of this development is represented by the papers appearing in the first sixty volumes of the *Journal*. The index has been made as complete as possible: thus, where a subject can be considered from more than one point of view, entries referring to each of them are given. In addition, the species on which the observations were made is also noted. It runs to upwards of two hundred pages, and is published by the Cambridge University Press as a supplement to the first number of volume 71 of the *Journal of Physiology*, issued in January.

THE Ministry of Agriculture desires to notify poultry farmers that it is now issuing a fowl pox vaccine at a charge of one penny per dose, with a minimum charge of 2*s*. 6*d*. covering a supply of 30 doses, with an instrument and brush for application. The vaccine has been extensively tested, it is free from danger, and causes no constitutional disturbance. It confers definite immunity of at least four months' duration. Cash must be enclosed with each order, which should be addressed to the Director, Ministry of Agriculture and Fisheries Veterinary Laboratory, New Haw, Weybridge, Surrey. The Ministry has also issued a bulletin (No. 26) on Johne's disease, which gives a full account of this important disease of cattle. The bulletin, price 3*d*. post free, may be obtained from the Ministry of Agriculture and Fisheries, 10 Whitehall Place, London, S.W.1.

At the annual general meeting of the Society of Public Analysts held on Mar. 4, the following officers for the year 1931 were elected: *President*, Dr. J. T. Dunn; *Hon. Treasurer*, Mr. E. B. Hughes; *Hon. Secretary*, Mr. F. W. F. Arnaud.

AMONG recent appointments made by the Secretary of State for the Colonies to the Colonial Agricultural Service are the following: Mr. H. R. Surridge, as agricultural officer, Fiji, and Mr. H. E. Box, as entomologist, Antigua, Leeward Islands.

SIR ARTHUR SMITH WOODWARD will deliver the Huxley Memorial Lecture at the Imperial College of

Science and Technology, South Kensington, on Monday, May 4, at 4 P.M. His subject will be "Modern Progress in Vertebrate Palæontology".

AT the annual meeting of the Geological Society of London held on Feb. 21, the following officers were elected: *President*: Prof. E. J. Garwood; *Vice-Presidents*: Mr. J. F. N. Green, Prof. J. W. Gregory, Dr. H. H. Thomas, and Prof. W. W. Watts; *Secretaries*: Mr. W. Campbell Smith and Prof. W. T. Gordon; *Foreign Secretary*: Sir Arthur Smith Woodward; *Treasurer*: Mr. F. N. Ashcroft.

THE Masters' Memorial Lectures of the Royal Horticultural Society will be delivered in the lecture room of the Society's new hall in Greycoat Street, Westminster, on Wednesday and Thursday, April 8 and 9, at 3.30 P.M., by Prof. Erwin Baur, on "New Scopes and New Methods of Plant Breeding" and "The Problem of Evolution". Sir Daniel Hall and Sir Frederick Keeble will take the chair on these occasions.

IT is announced by Northern News Services, Ltd., that Dr. Hjalmar Broch, director of the marine biology station of the University of Oslo, has been appointed by the Jugoslav Government to be director of the Institute of Deep-sea Research and Fishery Investigations in the Adriatic. The Jugoslav institute is being built at Split (Spalato), where all branches of science concerning deep-sea research will be represented, including zoology, botany, and oceanography. Local methods of fishing will also be investigated, with the view of modernising and rationalising these.

A NEW article of association of the Royal Zoological Society of New South Wales, giving the council power to confer the title 'fellow' on any member or associate member of the Society who has rendered distinguished service to Australian zoology, has recently been formulated. The council has conferred this title upon Dr. R. J. Tillyard, H. J. Carter, W. W. Froggatt, T. Iredale, A. F. Basset Hull, and T. C. Roughley, all of whom have contributed largely to scientific journals articles dealing with the various branches of Australian zoology. The title is purely an honorary distinction.

ACCORDING to the records obtained at Kew Observatory, the epicentre of the destructive earthquake which occurred in the Balkans at 1 h. 50 m. G.M.T. on Mar. 8 was near 41° N., 21° E. The disturbance was about four times as violent as the shock which occurred in the same region at 0 h. 16 m. G.M.T. on Mar. 7. According to a revised estimate, the position of the epicentre of this earlier shock is 42° N., 23° E. The earthquake which was felt in Japan on Mar. 9 was recorded as a large disturbance at Kew Observatory. A United States Coast and Geodetic Survey broadcast message gives the epicentre as 43° N., 140° E.

ON Mar. 13, Sir Frederick Gowland Hopkins, president of the Royal Society, unveiled, in one of the principal laboratories of the London School of Hygiene and Tropical Medicine, a memorial plaque in memory of the late Lord Wandsworth, who left a sum of £10,000 to found a scholarship for the promotion of medical research in one of the London medical schools. The ceremony was performed in the presence of Sir William Hamer and Dr. E. Deller, Principal of the University, and others, during an official inspection of the School by the University of London. In unveiling the tablet, Sir Gowland Hopkins expressed the hope that the work already done and the opportunities for the future which the scholarship afforded would be an abiding source of inspiration.

THE Association of British Chemical Manufacturers has issued an "Index to Acts of Parliament and Statutory Rules and Orders affecting the Chemical Industry". Copies of this publication (price 2*s*. net) may be obtained from W. Heffer and Sons, 4 Petty Cury, Cambridge.

SOME years ago, Dr. Marie Stopes suggested that coital interlocking between the glans penis and the cervical canal occasionally occurred in man. The phenomenon was, on anatomical grounds, scarcely credited (see NATURE, Oct. 25, 1924, p. 601, and Nov. 15, 1924, 719). Dr. Stopes now states (*C.B.C. Bull.*, No. 2, 1930) that the occurrence has been confirmed in 48 cases attending the Clinic for Constructive Birth Control and in others, 59 cases in all.

THE Kodak Research Laboratories have just issued the thirteenth volume of abridgments of their scientific communications published in 1929. There are 37 of them in the volume, by 32 authors. The subjects include physical, photographic, and physiological optics; organic, physical, and colloid chemistry; photographic theory, and practical photography. The abridgments are very full, giving all the essential details of the original papers.

THE winter, 1930–31, issue of *The Fight against Disease*, the quarterly journal of the Research Defence Society, contains an article by Dr. J. H. Burn on the use of animals for the standardisation of remedies, in which he points out that animal tests of activity are necessary not only for antitoxins and insulin but also for the arsenobenzenes. An account is given of the debate in the House of Commons upon Commander Kenworthy's Bill to prevent the application of public money to vivisection experiments, which suffered the unusual fate of being refused a first reading.

As a result of long-standing trials, the National Institute of Agricultural Botany at Cambridge is well qualified to give reliable advice to farmers, and, as is pointed out by the Institute, the selection of the right variety of a crop may make all the difference between success and failure. The publication of *Farmer's Leaflets* Nos. 2, 3, 4, and 5, dealing respectively with cereals for spring sowing, potatoes, lucerne, and sugar-beet, should, therefore, prove of immediate benefit to the farming community. The leaflets may be obtained post free on application to the Institute at Cambridge.

UNDER the title of "Canada 1931", the Dominion Bureau of Statistics has published a handbook of the present conditions in Canada (Ottawa: Dominion

Bureau of Statistics. London: High Commissioner for Canada). The small volume supplements the larger and more purely statistical "Canada Year Book" and gives enough comparative statistics to present a survey of most aspects of Canadian activity. The reviews of agriculture, mining, and the development of water power are useful summaries. A statistical appendix gives tabulated figures for the last ten decades in population, production, trade, and other matters. There is also a list of official sources of information relating to Canada.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A male fishery officer in the Fisheries Department of the Ministry of Agriculture and Fisheries—The Secretary, Ministry of Agriculture and Fisheries, 10 Whitehall Place, S.W.1 (Mar. 31). A biochemical assistant at the Hannah Dairy Research Institute, Auchincruive, Ayr—The Secretary, Hannah Dairy Research Institute, Auchincruive, Ayr (April 1). A junior technical examiner in the Lands Branch of the War Department—The Secretary, Civil Service Commission, Burlington Gardens, W.1 (April 16). A head of the science and engineering department of Highgate School—The Headmaster, School House, Highgate (May 10). An adviser in entomology for the Bristol Province under the Advisory Scheme of the Ministry of Agriculture and Fisheries—The Acting Registrar, The University, Bristol.

Our Astronomical Column.

The Corona without an Eclipse.—M. B. Lyot's experiments with a sensitive polarimeter from the summit of the Pic du Midi, which is 9439 feet high, undoubtedly indicate the most hopeful means of observing the corona without an eclipse. They are fully described in a bulletin dated Feb. 14 issued by Science Service, Washington, D.C. A screen was used to cover the image of the sun's disc, and the prominences were then visible without the aid of a spectroscope. The polarised light that he ascribes to the corona can only be traced for 3′ or 4′ above the sun's limb, so that the method only extends to the bright inner zone of the corona. It is only observed in one position angle at a time; but by rotating the instrument round the sun's limb, it can be studied in all position angles. Dr. Deslandres is hopeful that it may be possible to photograph the images thus obtained. The article recalls that François de Plantade, an assistant of Cassini, used the Pic du Midi for astronomical observations two centuries ago. It also refers to the attempts of Prof. Hale and Dr. Steavenson to photograph the corona from high mountains; they did not, however, employ a polarimeter. A complete check of the new method will be afforded when the moon is very near the sun, but not actually encroaching on the disc; if the method is sound, the dark disc of the moon should be discernible.

The System of ξ Ursæ Majoris.—This has long been known as an interesting double star with a period of 59·8 years; it has been followed through more than a revolution. In 1905, Norlund detected an oscillation in the bright star with a period of 22 months, indicating that it has a close companion. The fainter star was found to be a spectroscopic binary, with a period of 9·8 days, by the Lick observers in 1918. *Lowell Observatory Bulletin* 432 contains a discussion of the spectroscopic orbit by L. Berman. The discussion is complicated by the double orbital motion; the light-time changes considerably during the description of the large orbit. The 22-month orbit is turned nearly edgewise to us, and observers are asked to watch for a possible eclipse on Feb. 4 or 5, 1932. We see the 9·8-day orbit nearly fully open, so the radial motion in it is small. A very accurate parallax can be derived from a combination of the data; the adopted value is 0·126″, giving a distance of 26 light-years. The combined mass of the brighter pair is $1\frac{1}{4}$ sun; that of the fainter pair is equal to the sun. Both the visible components are about $1\frac{1}{4}$ times as dense as the sun. The semi-major axis of the 9·8-day orbit is 7,319,500 km.; that of the 59·8-year orbit is about 20 astronomical units. The spectrograms were measured by Mr. Berman and Miss Hobe; they determined their personal equations by measuring spectrograms of Venus, the radial velocity of which is accurately known.

Annuaire Astronomique Camille Flammarion, 1931.—This useful almanac (Observatoire de Juvisy; 12 francs) contains details of the positions of sun, moon, and planets, diagrams of the orientation of the solar equator in different months, data of all oppositions of Mars up to 1956, elements of Pluto with a diagram of its orbit and details of the two total lunar eclipses of 1931, which are both visible in England and France. There is an excellent table of the elements of the orbits of periodic comets, compiled by M. Baldet; it includes comet Schwassmann-Wachmann III (1930 *d*). There are also meteorological data and many useful tables of physical constants. One notes the interesting fact that Mt. Canigou can be seen from Marseilles projected upon the setting sun on certain days in February and October; the distance is 253 km., and the straight line joining the points is 120 m. below the sea at the middle point; the visibility depends on refraction.

A table of Easter up to 2319 may interest some readers. One notes that Easter occurs in March once in $4\frac{1}{3}$ years; it will not occur on Mar. 22 (its earliest date) until 2285. It is, of course, assumed that the present mode of reckoning will be continued.

Report of the Leyden Observatory for 1930.—The Report begins with acknowledgment of the gift of 110,000 dollars from the Rockefeller Foundation. It is being used for the construction of a photographic equatorial of 40 cm. aperture, which will be erected at Johannesburg, thus strengthening the connexion between Leyden and the Union Observatory. Dr. van den Bos has now become chief assistant at the Union Observatory. Prof. Hertzsprung and Mr. van Gent are there temporarily.

The meridian circle at Leyden was used for observation of the Eros-reference stars. The proper motions of the reference stars in the selected areas are being discussed; also those of stars in the Pleiades in connexion with Prof. Hertzsprung's investigation. Mr. Kuiper has observed double stars with the 10-inch refractor on 63 nights.

Mr. van Gent has photographed several southern fields with the Franklin Adams camera, and has detected 82 known and 28 new minor planets. Prof. de Sitter and Dr. Oort have investigated the radial velocities of the spiral nebulæ in relation to the theory of relativity and the rotation of the galaxy.

Research Items.

The Society Islanders.—A study of the physical characters of the Society Islanders by H. L. Shapiro, and based upon material collected in the field on the Bayard Dominick Expedition by S. Craighill Handy and Willowdean C. Handy, is published in vol. 11, No. 4, of the *Memoirs of the Bernice P. Bishop Museum*, Honolulu. Eighteen characters were examined and fifteen indices calculated on two hundred and two individuals. The measurements of 153 only are included here, as 49 were excluded on the ground of non-Polynesian admixture. From a study of the distribution of these characters, which show bi-modal and multi-modal curves common to both sexes, it is concluded that there is heterogeneity in the population. The impression of massiveness and size is borne out by the measurements. The stature of 171·35 cm. places them among the tallest people in the world. The head is of medium length and of more than medium width, giving an index markedly brachycephalic. Both face-height and width are large, producing a massive face. The forehead, however, is narrow, giving the distinctive character associated with the Polynesian. The nasal index is mesorhine; but the average dimensions are considerable, though they do not equal the average of the Samoans and Tongans. In bodily proportions and size the Society Islanders are relatively large. In general, the women display the same development as the men. Most of the Islanders have black hair. There are no blondes; but 13·14 per cent of the men and 15·15 per cent of the women have reddy-brown hair.

Tribes of the White Nile Province.—Some notes digested from reports and essays of members of the administrative staff by Mr. J. A. Reid are given in *Sudan Notes and Records*, vol. 13, pt. 2. The information has been collected since 1924. For practical purposes the province is divided into three areas: (1) the Kawahla group, (2) the Baggara group, and (3) the rest. The Kawahla group, the Hassania, Huseinat, and Kawahla proper, occupy the Geteina district and the riverain part of Dueim and Kawa, the first two being the predominant partners. They are now a river-dwelling, semi-nomadic folk, spending most of their time near the Nile, except when they go inland to cultivate their rainland and seek green pasture for their animals. As soon as the rains are over, they start cultivating the river flats and bring their animals to the water, where they remain until the next rains. They acquired their present *âār* by conquest. Though the land must have been held in tribal holding originally, individual ownership developed rapidly. Blood money, originally paid in camels, as they owned no cattle, is now paid in cattle or ready money. The Baggara group extend from the southern end of the province, just south of Kawa, to the Upper Nile boundary. They are, in a general sense, the semi-nomadic Arabs whose business in life is cattle-breeding and who ride on bulls, while they leave to slaves and others the cultivation of the ground. Even with extensive sheep owners, the flocks are of comparatively recent origin and are soon exchanged for wealth in cattle. During the rains, the Baggara move from the river and wells, the extent of their migrations being governed by the fly. Practically all cultivate, but it is not their main object. Land, to begin with, belonged to the tribes, being held by the chief as trustee; but there were very definite rights of usufruct. When, on the lighter lands, a man had cleared a piece of land, it would be only in very exceptional circumstances that he would be disturbed, and on his death it would pass to his heirs eventually. The rights of ownership are more marked on the heavier cotton-growing lands. "The rest" are tribes living on the eastern and western flanks of the centre of the province, of no great importance, and in some cases merely survivals which cling to their tribal identity.

Observations on Indian Annelida.—In the *Proceedings* of the Seventeenth Indian Science Congress, held at Allahabad (Calcutta: Asiatic Society of Bengal), abstracts of fifty-three zoological communications are given. The majority of the papers were on parasites, insects, fishes, and cytology. It is interesting to note that several post-larval *Polygordius*, probably allied to *P. lacteus*, were taken in the tow-net near Madras, and with them, early larvæ. The latter were kept under observation for a few days and proved to have an 'amnion', as in *P. lacteus*. Another paper dealt with the alimentary glands in a surface-feeding earthworm, *Eutyphœus*. These glands, formerly mistaken for calciferous glands, are not situated on the œsophagus but much farther back—a little behind the middle of the body. They occur in connexion with the typhlosole, open into the gut by several apertures, and have a special blood supply. Preliminary experiments appear to indicate that they have a digestive (peptic) function.

Ascidians of Porto Rico and the Virgin Islands.—In connexion with the "Scientific Survey of Porto Rico and the Virgin Islands", Dr. Willard G. Van Name has, in vol. 10, part 4 (New York Academy of Sciences; 2 dollars), described the Ascidian fauna of the region. A very clear account of the 35 species collected from the coasts of these islands is given, with the diagnostic characters of the families and genera concerned. Numerous plates and sketches are used in illustration. The ascidians of Porto Rico and the Virgin Islands are, as might be expected, typical tropical and subtropical forms, some of which are restricted to the region including the West Indies, Gulf of Mexico, Caribbean, and Bermuda, whilst others, such as *Tridemnum savignii* and *Styela partita*, are found in practically all the warmer seas of the globe. A close relationship exists between the ascidian fauna of the West and East Indies, 18 of the West Indian species being represented in the East Indian region. One West Indian species, *Perophora viridis* (Verrill), is considered identical with *P. listeri* (Forbes and Hanley) of European waters. Two species only, *Ascidiella styeloides* and *Microcosmus anchyloderus*, are restricted to Porto Rico and the Virgin Islands. It is interesting to note that the ascidians of these islands, with one exception—*Pyura antillarum* (from 496 fathoms), are littoral forms. A considerable amount of dredging has yielded no truly deep-sea forms. Hartmeyer's revised classification of the Tunicata (1915) is used throughout, except that Lahille's orders—Aplousobranchiata, Phlebobranchiata, and Stolidobranchiata—are substituted for the Krikobranchia, Dictyobranchia, and Ptychobranchia of Seeliger. In addition, the distinct genus *Perophora* of Hartmeyer is included under the Ascidiidæ. The Botryllidæ are regarded as a distinct family of the order Stolidobranchiata. Linde (1923) and Michaelsen (1928) include them as a subfamily of the family Styelidæ, to the compound forms of which they are, without doubt, closely related.

Digestion of Cellulose by Insects.—Although a very large group of insects feed on woody tissues of plants and even on dry wood consisting almost entirely of cellulose, practically nothing is known as to whether these insects are able to digest cellulose. The problem

has been investigated successfully only with regard to wood-eating termites, in which the digestion of cellulose was found by Cleveland to depend on the presence, in their intestinal tract, of symbiotic Protozoa (Flagellates). Many other wood-feeding insects were investigated by Buchner and his pupils from a purely anatomical point of view, and in the majority of them various symbiotic micro-organisms, often harboured in special organs (for example, the so-called 'fermentation chambers'), were discovered. This anatomical evidence was considered sufficient to postulate a theory that the micro-organisms must assist their hosts in the digestion of cellulose, and this theory is commonly accepted. However, recent investigations by W. Ripper (*Zeit. vergl. Physiologie*, 13 Bd., 2 Heft, 1930), who used biochemical methods, throw considerable doubts on the assumed rôle of symbiotic micro-organisms in wood-eating insects. This author has proved the presence of a cellulase (cellulose-digesting enzyme) in the intestinal juice of several insects not possessing symbionts, which result suggests that the digestion of cellulose can occur without the assistance of symbionts. On the other hand, no cellulase was found in the 'fermentation chambers' of other wood-boring larvæ, although these organs are required by Buchner's theory to harbour cellulose-digesting micro-organisms. Again, in the case of certain unspecialised wood-borers, the percentage of cellulose in the wood consumed and in the excreta proved to be the same. Thus some wood-borers do not utilise any of the cellulose of their food, others can digest it without symbionts, while the organs harbouring symbionts may bear no relation to the digestion of cellulose. It appears that further research on biochemical and physiological lines is necessary for the elucidation of this highly interesting and complicated problem.

The Tetraploid Chinese Primrose.—*Primula sinensis* has been a subject of genetic investigation for many years. A recent paper by Mrs. Sverdrup Sömme (*Jour. Genetics*, vol. 23, No. 3), who formerly worked at the Merton Laboratory, is concerned with the genetics and cytology of the tetraploid form. This has arisen at various times in different strains and the view is favoured that it results from a suspended mitosis in the fertilised egg. It is a stouter plant, a cell giant, with 48 chromosomes, and is less fertile than the diploid. In the first studies of this tetraploid, Gregory found certain factors duplicated and he assumed that in meiosis the chromosomes would mate in pairs derived from either parent. Mrs. Sömme, however, finds that the genetic behaviour is that which would be expected if random pairing takes place between any two of the four homologous chromosomes in each set. The two hypotheses are tested as regards the factor (*S*) for heterostylism, *Gg* for green or red stigma, and other pairs of factors. Plants of constitution S_2s_2 gave an F_2 ratio of 35 : 1, and a ratio of 5 : 1 in back-crosses, strongly supporting the theory of random conjugation between the four chromosomes. Only two of the genes studied show complete dominance when present in a single dose. Three of the genes show linkages in the tetraploids, which correspond to the linkages in the diploid. But crossing-over can take place between any two of the four homologous chromosomes. In diakinesis, some of the sets of four are seen to be arranged as quadrivalent chromosomes, but usually only one or two are present in each pollen mother cell. In all the attempts to cross $2n$ and $4n$ plants, only three triploid (sterile) plants were obtained. This extensive and accurate record of genetic experiment is concluded with a discussion of tetraploidy as a factor in evolution, in which the author justly argues that the multiple factors in wheat and other plants have probably arisen through polyploidy.

Cambrian Arthropods.—Two of the many remarkable fossils discovered by Walcott in the Middle Cambrian of British Columbia have been re-studied by G. E. Hutchinson (*Proc. U.S. Nat. Mus.*, **78**, art. 11, pp. 1-24, pl. 1; 1930). One of these, a crustacean named *Opabinia*, was placed by Walcott in the Anostraca, and this view of its position has been confirmed by later writers. The most conspicuous feature of the head is a large cylindrical process in front which, in living forms, is developed from the fused internal or frontal appendages of the antennæ in the male. In structure *Opabinia* agrees with living Anostraca in many respects, but differs in the smaller number of trunk segments, the larger number of appendage-bearing segments, the presence of only one or two post-pedigerous segments, and the absence of branchiæ and a caudal fork. On account of these differences it is considered that *Opabinia* should be placed in a separate sub-order of the Anostraca. The presence of this genus in a marine deposit is of interest since the living Anostraca have a fresh-water habitat. *Rochdalia*, from the Middle Coal Measures of Lancashire, is thought to be allied to *Opabinia*, and was apparently of fresh-water habit. The other genus studied by Hutchinson, *Aysheaia*, was regarded by Walcott as a polychæt annelid, but later authors have been impressed by its resemblance to the living Onychophora (*Peripatus*, etc.), and further study confirms this view of its relationship. Some differences in structure, however, support the opinion put forward by Hutchinson that the Onychophora should be divided into orders: 1, Protonychophora, to include *Aysheaia*; 2, Euonychophora, to include the living forms. The Cambrian genus is of interest as being marine, whereas the living representatives are terrestrial. C. E. Resser (*Proc. U.S. Nat. Mus.*, **76**, art. 9, pp. 1-18, pls. 1-7; 1929) describes and figures some beautifully preserved specimens of phyllocarid crustacea from the Lower and Middle Cambrian of British Columbia, Pennsylvania, and Manchuria.

Middle Ordovician in Central Norway.—In Ottadal, central Norway, a remarkable rock known as 'serpentine conglomerate', and hitherto regarded as a picrite lava or a tuff-agglomerate, has been found by P. A. Øyen and Iver Haugen to yield a rich though obscure fauna. Some three thousand specimens have been placed in the hands of the Swedish State-geologist, Herman Hedström, who has just published a preliminary report (*Avhandl. Norske Videnskr.-Akad.*, 1930, No. 10, 10 pp., 2 pls.). The shells have been changed into iron carbonate and details are often lost; but enough remains to identify the fauna as corresponding with the *Orthoceras* Limestone and *Asaphus expansus* beds of Sweden—the 3 c γ and β of Norway. Gastropods abound, trilobites and cephalopods are fairly common, and there are also brachiopods and lamellibranchs. Hedström regards the rock as a true conglomerate, contemporaneous with the fauna and formed from older peridotites. In any case, this discovery will have to be reckoned with, in interpreting the geology of central Norway.

Datum Planes for Charts.—The problem of satisfactory datum planes for maps, and particularly hydrographic charts, is fully discussed by Mr. H. A. Marmer in "Chart Datums" (U.S. Coast and Geodetic Survey, Special Publication 170). The arbitrary datum level is clearly of little value for charts, since it gives no absolute information regarding depths. Moreover, it is clear that the datum plane should be one that is capable of recovery even if all bench marks are lost. Tidal datum planes alone are satis-

factory. A high-water datum may be very useful for certain purposes such as the clearance of bridges or warehouse construction along the water front, but it is unsatisfactory for nautical charts, inasmuch as it gives a false idea of security. Mean sea-level datums are fairly satisfactory but may cause trouble or danger in shoal areas. The needs of the sailor are best served by low-water datum planes, but the determination of these is not an easy matter, owing to periodic variations in the tide. Mr. Marmer discusses the nature and extent of these variations. A mean low-water datum is relatively easily determinable on any coast and may be fairly satisfactory. It is used on the charts covering the Atlantic coasts of the United States. A datum of lower low-water is reached from half as many observations as that of mean low-water. This is most suitable for coasts on which the tide is of the daily and not of the semi-daily type. It is used on the Pacific coast charts of the United States. Another datum that can be used is that of spring low-water. This, of course, requires a long time for determination, and tends, in use, to give an appearance of unnavigability to many waters, and also to indicate rocks and reefs which are rarely visible to the mariner.

Recent Researches on Relativity.—Lemaître and Sir Arthur Eddington have shown that our actual universe may probably be considered as expanding from an initial state, something like 'Einstein's world' filled with matter, towards a limiting state like 'de Sitter's world', which is empty, or rather has all the matter swept into unobserved corners. It has been suggested that the concentration of matter, originally uniformly distributed, into local condensations may have started this expansion. To test this hypothesis, W. H. McCrea and G. C. McVittie (in *Monthly Notices Roy. Ast. Soc.*, Nov. 1930) study non-stationary universes where there is a single condensation of matter at the origin. This is proved to lead not to an expansion as anticipated, but to a contraction. Dr. G. C. McVittie also contributes (*Proceedings* of the Edinburgh Mathematical Society, ser. 2, vol. 2, part 3, Jan. 1931) a comparison between the general relativity theory and Einstein's newer unified field theory. It is shown that the latter, applied to the problem of a particularly simple type of field with axial symmetry, gives results which do not appear to correspond to physical facts. The conclusion can scarcely be evaded that Einstein's latest theory, at any rate in the form at present published, contains serious defects.

Artificial Disintegration by α-Particles.—The paper by J. Chadwick, J. E. R. Constable, and E. C. Pollard in the February number of the *Proceedings of the Royal Society*, in which they describe their new experiments on the disintegration of the nuclei of light elements by α-particles and discuss these and the recent experiments of Bothe and Fränz and of Pose, although leaving much detail still to be supplied, marks a definite advance in knowledge of the properties of nuclei. The assumptions needed to explain such facts as are known at present are few and simple: the nuclei are supposed to have definite levels for protons and α-particles; to be composed of these and electrons, the number of the α-particles being as large as possible; all the α-particles of a stable nucleus are supposed to be in the same energy level, but not more than two protons can be put into the same proton level. Two main types of disintegration are supposed possible, in one of which the α-particle is captured by the nucleus—as appeared to be so in the cases of the disintegration of nitrogen photographed by Blackett—and in the other, the proton is ejected without capture of the α-particle. The evidence for the latter type is rather unsatisfactory, but it is of particular importance, since the continuous distribution of energies amongst the protons produced in this way could give immediately the level of the proton in the nucleus; disintegration with capture of the incident particle gives a 'line spectrum' of velocities for the protons. The changes in energy involved in the disintegration, which can be calculated from these experiments, also extend Aston's measurements of the mass-defects of nuclei with the mass-spectrograph, and in some cases furnish an independent check on these, although most of the nuclei formed in the disintegrations have not been studied with positive rays, and many are indeed rare. It is mentioned that the production of γ-rays from light elements by α-particle bombardment, which was recently reported by Bothe and Becker (see NATURE, Feb. 21, p. 288), has also been detected by H. C. Webster in the Cavendish Laboratory.

Solubilities in Hydrogen Fluoride.—A comparison of the solvent properties of liquid hydrogen fluoride and of water with respect to salts is possible from some results with the first solvent, which are communicated in the January number of the *Journal of the American Chemical Society* by Bond and Williams. The solubility of lithium hydrogen fluoride was measured between 0° and 40°. Zinc, magnesium, and calcium fluorides were found to be very insoluble; chromium fluoride is quite soluble; potassium iodide reacts with hydrofluoric acid. There is a fair similarity in the solvent action of water and hydrofluoric acid with the salts used. A determination of the critical temperature of hydrogen fluoride, made with a special apparatus, gave 230·2°.

Conductivity of Electrolytes in Nitromethane and Nitrobenzene.—The *Journal of the Chemical Society* for January contains two papers by Sir H. Hartley, Murray-Rust, Hadow, and Wright on the conductivities of some salts in nitromethane and nitrobenzene. In the case of nitromethane, only tetraethylammonium salts gave a linear relation between equivalent conductivity and $\sqrt{c}$, and these also show good agreement with the Debye-Hückel-Onsager equation. All the other salts show large divergences from ideal behaviour. Some of them are weak electrolytes in nitromethane, although they all behave as strong electrolytes in methyl and ethyl alcohols. Since the dielectric constant of nitromethane is greater than those of the alcohols, the results show that ionic association is not entirely controlled by the electrical forces between the ions. Perchloric acid is a fairly strong acid in nitromethane, and the mobility of the hydrogen ion is 63. Thus, this ion has not the abnormally high mobility in nitromethane which it possesses in hydroxylic solvents. Other acids appeared to be very weak in nitromethane. In nitrobenzene, tetraethylammonium picrate and perchlorate are strong electrolytes, and the results are in agreement with those calculated from the Debye-Hückel-Onsager equation, but silver perchlorate is appreciably associated. Perchloric acid is an electrolyte of intermediate strength, and the mobility of the hydrogen ion is 43, which shows that it is not abnormal, as in hydroxylic solvents. Hydrogen chloride, benzene sulphonic acid, and benzoic acid are very weak electrolytes. Nitrobenzene is similar to nitromethane as an ionising solvent, but the tendency towards ionic association is rather greater in the former. The dielectric constants are 35 and 37 respectively.

Resolution of *dl*-Menthol.—NATURE, Mar. 14, p. 421. Last line but two of paragraph: For "*d*-menthol" read "*l*-menthyl *d*-camphor-10-sulphonate".

Milk Tests in Lanarkshire Schools.*

THE Department of Health for Scotland has recently issued a report on the investigation into the effect of the addition of milk to the diet of school children. The data have been compiled and annotated by Dr. Gerald Leighton, Medical Officer (Foods), and Dr. Peter L. McKinlay, Medical Officer (Statistics).

Twenty thousand children were concerned in the experiment, 10,000 being given a daily ration of milk and a like number being used as control subjects. All the milk used was Grade *A* (Tuberculin Tested). Half of the milk was given in the raw state and half was pasteurised.

The schools selected for the tests were all situated in the densely populated industrial part of the county. While no account was taken of the distress prevalent in these localities in the selection, it has been estimated that one-third of the children came from homes in which there was unemployment, complete or partial. The ages of the subjects ranged from five years to twelve years. The sexes were balanced in each age group.

The teachers showed great interest in the experiment, and their "remarks" on the various subjects are often enlightening. One teacher noticed that "in the playground buoyancy and pugnacity developed to an alarming extent". Another states that a little girl increased in vitality to such an extent that she boasted to her teacher of her ability to fight her big brother.

While the physical benefits of the experiment made themselves fairly obvious, it was not easy to estimate the mental improvement. However, many teachers have reported great improvements in mental alertness, especially among the younger children. Others say that some of the children became drowsy. One boy, who hitherto was very backward in reading, improved greatly and became very smart in reading, arithmetic, and history. Another child, formerly very morose and sullen, has become bright and talkative.

There are complete records of the progress of 17,159 children. These records are in three parts—(*a*) Controls, (*b*) children fed with raw milk, (*c*) children fed with pasteurised milk. These are further subdivided according to age and sex.

Tables were prepared in such a way that not only the average increase in height or weight for the whole group, but also the average increase in height or weight for children of a given initial height or weight could be calculated. In view of the fact that there were definite differences of weights and heights in the controls compared with 'feeders' at the beginning of the experiment, it was considered advisable to inquire whether the amount of growth within this period was affected to any appreciable extent by original physique: that is, whether the heavier or taller child added more or less to its height or weight than the lighter or shorter child. For this purpose coefficients of correlation between original weight and original height and change in height were calculated for the control group. From these results it was inferred that there was no uniform tendency for gain in weight or height to be influenced by original weight or height.

The conclusions may be summarised as follows:

(1) The addition of milk to the diet of school children is reflected in a definite increase in the rate of growth, both in weight and height.

(2) There is no obvious or constant difference in this respect between the sexes. There is little evidence of definite relation between the age of the children and the amount of improvement. The results do not support the popular belief that the younger children derived more benefit than the older children. As manifested merely by growth in weight or height, the increase found in younger children through the addition of milk to the usual diet is certainly not greater than, and is probably not even so great as, that found in older children.

INCREASE IN WEIGHTS (IN OUNCES) IN THE THREE GROUPS.

Age.	Boys.			Girls.		
	Control.	Raw Milk.	Pasteurised Milk.	Control.	Raw Milk.	Pasteurised Milk.
5	11·64	14·88	15·65	7·00	14·50	6·62
6	13·75	13·51	9·96	11·21	10·61	10·05
7	11·17	14·85	15·55	8·90	11·22	12·94
8	11·38	14·21	15·21	9·77	13·40	13·37
9	9·53	13·43	11·83	7·87	13·81	12·52
10	7·10	13·53	10·39	9·51	15·08	18·96
11	6·14	12·74	11·05	12·62	24·92	17·08

INCREASE IN HEIGHTS (IN INCHES) IN THE THREE GROUPS.

Age.	Boys.			Girls.		
	Control.	Raw Milk.	Pasteurised Milk.	Control.	Raw Milk.	Pasteurised Milk.
5	0·75	0·95	0·94	0·86	0·64	0·87
6	0·80	0·87	0·87	0·80	0·86	0·84
7	0·76	0·87	0·82	0·75	0·84	0·81
8	0·74	0·82	0·79	0·71	0·81	0·78
9	0·69	0·80	0·74	0·66	0·76	0·78
10	0·68	0·76	0·68	0·71	0·79	0·72
11	0·69	0·74	0·70	0·77	0·86	0·81

(3) In so far as the conditions of this investigation are concerned, the effects of raw and pasteurised milk on growth in weight and height are, so far as can be judged from this experiment, equal.

Dr. J. P. Kinloch, Chief Medical Officer of the Department of Health for Scotland, says, in a prefatory note, that the scheme was made possible by a grant of £5000 from the Empire Marketing Board, which approved its purpose and the selection of Lanarkshire for the experiment. The Distress in Mining Areas (Scotland) Fund financed the experiment also, by a grant of £2000. Individuals and firms interested in the dairying industry contributed £477. The results, states Dr. Kinloch, demonstrate that the addition of milk to the children's diet results in improved physique and mental alertness. They also suggest that, apart from its own food value, milk enables the other constituents of the ordinary diet to be fully utilised as growth factors.

It is significant that, by powers conferred by the Education (Scotland) Act, 1930, local authorities may make a ration of milk available for school children. The exercise of these powers would, Dr. Kinloch states, affect 800,000 children in Scotland, and, by improving their physical and mental well-being, would have a powerful influence in improving the quality of the Scottish race.

JOHN TAYLOR.

* Department of Health for Scotland. Milk Consumption and the Growth of Schoolchildren. By Dr. Gerald Leighton and Dr. Peter L. McKinlay. (Edinburgh and London: H.M. Stationery Office, 1930.) 3*d*. net.

Modern Metal Cleaning.

THE increasing use of electroplating processes for the protection from corrosion, the reduction of wear, the building up of worn parts, or the actual manufacture of components, coupled with the fact that the production of an adherent metal coating depends on the complete removal of all foreign matter from the basis metal, makes an account of the means whereby this clean surface may be obtained by mass production methods one of considerable importance. A paper on the subject was presented by Messrs. L. Wright and F. Taylor to the Electroplaters and Depositors' Society recently.

Cleaning tanks of steel, iron, or wood, with or without electrical connexions, still remain the most common means of achieving this end, and large volumes of cleaning solution, at a steady temperature, are required if the dirt is not to be redeposited on the work. Such tanks may be heated by gas or by electrical immersion heaters; but a steam coil, placed at that side of the tank opposite the overflow dam, is the best. This causes the solution to boil towards the dam, carrying with it surface scum or oil. The coil should be shielded with perforated sheet metal, and the solution, gushing through the holes, effects adequate agitation. For the general run of cleaning, the solution should be maintained at the boiling point, which has the incidental advantage that as the metal expands the dirt is loosened.

Agitation by compressed air has the disadvantage that it rapidly cools the solution and promotes foaming. In the absence of steam heating, the most convenient method for rapid and efficient cleaning is by an arrangement of paddles.

Electric cleaning, which is rapidly coming into general use, adds a mechanical to the chemical effect. The passage of the direct current though the solution liberates hydrogen in small bubbles at the cathode, forces the particles of dirt away from the metal, and carries them into the bulk of the solution, where they are readily emulsified and suspended. The potential across the tank should be of the order of 6 volts, and the cathode current density 30-40 amp. per sq. ft. Any danger of metals such as tin, lead, or zinc accumulating on the cathode may be eliminated after the cleaning by temporarily making the article the anode; this removes any such adherent film. The accumulation of colloidal hydroxides can be avoided by the occasional use of supplementary steel electrodes, on which the colloidal hydroxides adhere. The electrodes are from time to time removed from the bath and the accumulations scoured off.

Effective rinsing after cleaning, in clean, soft water, is as important as the cleaning itself, as it washes away the dirt which the cleansing solution has loosened and softened. Hard water reacts with the soap films forming a calcium soap, which adheres to the work. The use of two tanks is recommended, the first hot and the second cold; and after rinsing, the article should be chemically clean, as shown by the surface being uniformly wetted.

Meteorology in India.*

THE year 1929–30 was one of exceptional expansion and reorganisation in the Meteorological Department of the Government of India, arising from the formation of new air-routes. To meet the meteorological requirements of such air-routes, and of additional contemplated air-routes not yet in operation, as laid down in various international recommendations, it was found necessary to arrange for the preparation, twice daily, of weather charts at regional forecast centres, and to raise the status of most of the third class weather stations to second class status. A new forecast centre in charge of a fully qualified meteorologist had to be opened at Delhi in November 1929 in order to supply weather forecasts to the State Air Mail and other aviators flying on the Jodhpur-Delhi and Delhi-Allahabad air-routes, while the existing forecast centre at Karachi made itself responsible for forecasts for the Karachi-Jodhpur route. Further expansion was necessitated by the imminence of additional air-routes from Delhi to Calcutta and Calcutta to Rangoon, and detailed proposals for meeting this need were submitted to the India Government.

One of the most urgent needs of aviators is knowledge of the winds to be expected at various altitudes, in order that flying may be done with the maximum of wind assistance. This has necessitated an increase of stations equipped for making observations of upper wind by means of pilot balloons, an increase which has reacted upon the organisation of the Upper Air Observatory at Agra, where the plant for producing the hydrogen required for the balloons is situated; an increase both of the plant and of the staff of that observatory has therefore become essential.

All this activity on the side of organisation and equipment has not prevented useful research work from being done. Many subjects have received especial attention, among which may be noted that of the electrical charge of thunder-clouds, which has resulted in observational support being found for Simpson's breaking drop theory. Microseisms caused by earth-tremors due to ocean waves have been studied in relation to the storms on the seas around India, and interesting relationships have been obtained; while the Upper Air Observatory at Agra has made a special study of the 'nor'-westers' that occur in Bengal in spring and early summer, a special expedition being organised in 1929 for this purpose. These brief notes indicate only a few of the activities of a meteorological service that is rapidly pushing its way into the forefront of investigational enterprise.

* Report on the Administration of the Meteorological Department of the Government of India in 1929–30. Pp. 25+4 plates. (Calcutta: Government of India Central Publication Branch, 1930.) 1 rupee; 1s. 9d.

University and Educational Intelligence.

CAMBRIDGE.—The Natural Sciences Tripos Committee has issued a report to the University and has made the following recommendations, to take effect after the examination to be held in 1933: (1) the examination in mathematics in Part I. of the Natural Sciences Tripos shall be conducted by two special papers instead of by means of the papers set in Part I. of the Mathematical Tripos. The total maximum of marks allotted to mathematics shall be half that assigned to each of the other subjects; (2) all candidates for Part I. of the Tripos shall be required to offer not less than three subjects exclusive of mathematics; (3) the subject mineralogy in Part I. of the Tripos shall be redefined to include both crystallography and petrology. It is also recommended that the written examination in mineralogy consist of two papers: (1) the elements of crystallography, crystal optics, and descriptive mineralogy; (2) (*a*) crystallography and crystal physics, (*b*) crystal structure and crystal chemistry, (*c*) mineralogy and ore deposits, (*d*) petrology. Two of these sections only are to be taken, with the restriction that (*d*) shall be taken only by students who offer also the subject of geology. This report will be discussed next term.

In NATURE of Mar. 14, p. 424, it was stated that Dr. J. Wishart had been appointed University lecturer

in statistics. This is incorrect. Dr. Wishart has been appointed to the readership in statistics, to succeed Mr. G. Udny Yule. Mr. Udny Yule, formerly lecturer in statistics, was appointed reader on Jan. 1 last, but he will vacate this post at the end of the present academical year. A lecturer in statistics is to be appointed by the Faculty of Economics.

EDINBURGH.—The Senatus Academicus of the University has resolved to confer the honorary degree of Doctor of Laws, at the graduation ceremonial on July 2, on the following among others: Dr. E. J. Allen, Director of the Marine Biological Laboratory, Plymouth; Sir George Berry, M.P. for the Scottish Universities, formerly lecturer in opthalmology in the University of Edinburgh; Sir Walter Morley Fletcher, Secretary of the Medical Research Council.

OXFORD.—Congregation has accepted with thanks a gift of £200 from Mrs. Clara Brooks in memory of her son, Clement C. Brooks, formerly on the staff of the Imperial Forestry Institute, who was killed in a bicycle accident. The interest of this sum is to be devoted to the purchase of entomological books and apparatus for the use of the Forestry Department.

APPLICATIONS are invited by the Salters' Institute of Industrial Chemistry for a limited number of fellowships for chemists of post-graduate standing. The fellowships are each of the value of from £250 to £300 and their object is to afford additional and special training, at home or abroad, preparatory to a career in industrial chemistry. The Institute is also offering a limited number of grants-in-aid to young men and women employed in chemical works in or near London, of 17 years of age and upwards, who desire to extend their education for a career in chemical industry. Applications, in each case, should be made by May 1 at latest to the Director of the Institute, Salters' Hall, St. Swithin's Lane, E.C.4.

THE March issue of the *School Science Review* devotes sixty pages to reports of the proceedings of the Science Masters' Association at the Birmingham meeting held early in January (see also NATURE, Jan. 17, p. 111). The presidential address by Sir Charles Grant Robertson, vice-chancellor of the University of Birmingham, pleads the claims of biology to general recognition as an essential constituent in the school science curriculum. The general principles of science cannot be imparted by instruction limited to physics, chemistry, and mathematics, and the omission of biology is stigmatised as a crime against science. Sir Charles invited the Association to ask the Royal Society to appoint a small but representative committee to attack the problem of where, when, and in what system of allocation the teaching of science ought to begin and be carried on alike in the schools and the universities. In a discussion on science education of the boy up to eighteen, Prof. F. W. Burstall, vice-principal of the University, pointed out that in competition with the other sciences, biology inevitably suffers from the handicap that it is generally believed to be not so likely to help a boy to earn a living when he leaves school. A discussion on the subject of 'general science' disclosed a remarkable consensus of opinion in favour of the teaching of some biology to all pupils as an element of 'general' science, and an interesting description was given of a course arranged at Harrow as an introduction to science, occupying five periods weekly during one term. Prof. A. W. Nash, professor of petroleum technology in the University, addressed the Association on the work of the physicist and chemist in the petroleum industry; and the Bishop of Birmingham gave a lecture on "A Finite Universe?" The *Review* gives reports of both addresses.

Birthdays and Research Centres.

Mar. 22, 1868.—Prof. A. FOWLER, F.R.S., Yarrow research professor of the Royal Society and professor of astrophysics in the University of London, Imperial College of Science, South Kensington.

In view of the considerable number of research students, an attempt is made to cover a wide field of spectroscopic research. Continued attention is being given to the spectra of elements at successive stages of ionisation, and to the production and analysis of band spectra. Some progress has also been made towards the establishment of standard wave-lengths in the ultra-violet and Schumann regions of the spectrum. New work contemplated is the investigation of problems involving intensities and contours of spectral lines, and work on hyperfine structure, for which equipment has recently been provided.

At present I am specially occupied with an investigation of the spectra of flames, in the belief that our present knowledge as to the molecular origins of numerous bands will throw considerable light on some of the processes of combustion.

Mar. 22, 1868.—Prof. ROBERT A. MILLIKAN, chairman of the Executive Council of the California Institute of Technology and director of the Norman Bridge Laboratory.

I am still pursuing quite intensively my studies in the field of the cosmic radiations; for they have relations to meteorology not yet fully explored and their values at very high altitudes still have something to teach us about the precise nature of the cosmic atom-building processes. Also, as an adjunct to these studies, I am interested in the problem of the origin of the very heavy elements and, as a possible clue to its solution, am collecting further data, by a new method, on the terrestrial distribution of the radioactive elements. Artificially stimulated radiations of high penetrating power are also a part of the programme.

Mar. 25, 1863.—Dr. SIMON FLEXNER, For. Mem. R.S., director of The Rockefeller Institute for Medical Research.

The constantly growing number of those diseases of man, the lower animals, and plants, shown to be brought about by filterable agents or viruses, emphasises their known significance. Among human beings, a disease of this character is poliomyelitis or infantile paralysis. The modes of infection and of extension of the virus of this disease are questions of outstanding importance. Ever since 1909, when the first serial transmission of the disease to monkeys was accomplished (Flexner and Lewis), these questions have commanded attention. The indications, then secured and since confirmed, are to the effect that the virus is nerve conducted, as it enters and even as it leaves the body of infected human beings and animals via the respiratory mucous membranes.

Not only is this finding of importance in so serious a disease as poliomyelitis, but corresponding questions are of high interest in connexion with virus diseases generally, as is also the question of the precise nature (chemical or otherwise) of the viruses themselves.

Mar. 27, 1855.—Sir J. ALFRED EWING, K.C.B., F.R.S., formerly principal and vice-chancellor, University of Edinburgh; previously director of naval education and professor of mechanism and applied mechanics, University of Cambridge.

I am too old now for individual research. But a long experience of laboratories and of administration

can still be turned to account in committee work of the kind that is increasingly done under such official bodies as the Department of Scientific and Industrial Research.

I have learnt to value committees as instruments of research. Often they achieve results which would otherwise be out of reach. It has been said of them that they keep minutes and waste hours. The jibe would be pointless if it did not contain a half truth. But in fact, when sensible men serve on a committee, not much time is wasted. One finds that in some kinds of research, especially in the application of science to industry, the directing is best done by a committee.

In a committee, an old member, particularly when he happens to be in the chair, can do much to check waste of time. His very age becomes a useful asset. It has developed his historical sense; it gives him a sort of authority. He will focus attention on essentials. He will explore the minds of his colleagues, collect their ideas, induce each to contribute, and finally lead them to discover, perhaps to their surprise, that they are in agreement. A committee is a fluid holding potential wisdom in solution, from which conclusions are to be crystallised out. The process should not be hurried; but if, in the long run, a report issues which has some of the definiteness of a crystal, the time of the committee will not have been misspent.

Societies and Academies.

LONDON.

Royal Society, Mar. 12.—**E. W. Fish**: On the reaction of the dental pulp to peripheral injury of the dentine. A series of earlier experiments in which diffusible dyes were placed in the pulps of human teeth indicated that when primary dentine is injured at the periphery either by caries or attrition, the whole tract of affected tubules dies and becomes walled off from the pulp by secondary dentine. The nature of the reaction is found to vary with the severity of the lesion. The usual result is that the pulp ends of the injured tubules are sealed off by a deposit of calcium salts, and this is followed by a deposit of secondary dentine.—**E. B. R. Prideaux**: The combination curves, hydrogen ion regulating power, and dissociation constants of gelatin. The properties of gelatin as an ampholyte have been deduced from the combination curves, in which *p*H is expressed as a function of added acid or alkali. Considerable differences were noted between the combination curve of gelatin and those of amino acids. By means of equations which express the simultaneous relations: (*a*) absence of inflection at the isoelectric point, (*b*) the existence of the isoelectric condition; the constants of the basic and acidic dissociations have been calculated on the assumptions that gelatin consists mainly (i) of undissociated molecules, (ii) of amphoteric ions at its isoelectric point. On either theory, three constants are obtained, of which one acidic and one basic constant are nearly equal to one another.—**R. Snow**: Experiments on growth and inhibition. Since it had been found previously (*New Phytologist*, vol. 28, p. 345; 1929) that in older and taller pea seedlings the young leaves near the apex inhibit the axillary buds near the base of the stem more strongly than in very young short seedlings, experiments were carried out to test whether the increase in strength of inhibition is due to the greater length of intervening stem. It is concluded that the strength of inhibition increases with increasing length of intervening stem. Axillary buds normally grow to a certain length before they are stopped by inhibition, and they are susceptible to inhibition during their early growth as well as later. The interpretation of the increase of inhibition is briefly discussed.—**C. H. Lea**: The effect of light on the oxidation of fats. A quantitative iodimetric method for estimation of the peroxide oxygen present in rancid fats is described. By this means it is possible to follow the atmospheric oxidation of pure fats or of animal fats in the tissue, and, in conjunction with a suitable source of light, to forecast the relative susceptibilities of fats to oxidation. This method, with a quantitative modification of the Kreis test, has been used to investigate the effect on the oxidation of fats.—**H. Munro Fox** and **H. Ramage**: A spectrographic analysis of animal tissues. Tissues of annelids, molluscs, man, and some other animals have been studied. Iron and copper were present in all kinds of protoplasm investigated. Manganese was widely distributed. The manganese content of tissues varies with the locality in which a given species of animal lives. Nickel and cobalt occurred spasmodically, the former being more frequent. Except in one case, all high concentrations of nickel were accompanied by cobalt. In one tissue only did cobalt occur without detectable nickel. Lead and silver both exhibit an irregular distribution (see also NATURE, Nov. 1, 1930, p. 682).—**A. S. Parkes**: The reproductive processes of certain mammals (1). *Cricetulus* failed to breed under laboratory conditions, but it was found possible to investigate the cyclic changes occurring in the non-pregnant females, about half of which possessed perfectly normal reproductive organs. The cycle is very similar to that of the mouse. Cornification of the vaginal epithelium, diagnosed in the live animal by examination of the vaginal contents, was found to be associated with the period of ovulation. The average length of cycle was a little under five days, and the average number of follicles maturing at one period of ovulation was eight.—**F. G. Spear**: The delayed lethal effect of radium on tissue cultures *in vitro*—comparison of continuous and spaced radiation. It was found to be immaterial whether the radiation was given in one dose of six hours or in six fractional doses of 60 minutes each at 24 hourly intervals.

LEEDS.

Philosophical and Literary Society, Dec. 9.—**G. J. Blakey**: The parabolic developable of the trinodal cubic surface. The following results are due to Prof. A. E. Jolliffe and W. P. Milne: "There is a sextic envelope $\Gamma_6 \equiv J_6 - U_2 I_4 = 0$ (where J_6 and I_4 are respectively the harmonic and equiharmonic envelopes of the plane quartic curve, and U_2 is a conic), which touches the 24 inflexional tangents of the quartic, and the 12 bitangents of a Steinerian Complex. The conic U_2 is a sextangent conic of J_6, and there are 63 such conics corresponding to the 63 Steinerian Complexes". Dr. Blakey has carried out the analogous investigations in the case of a trinodal cubic surface.—**E. C. Stoner**: The specific heat of electricity in ferromagnetics. The theory of the specific heat of electricity based on the application of the Fermi-Dirac statistics is inadequate, as it leads to values incorrect in magnitude and sign. A metal is treated as an equilibrium distribution of atoms, ions, and free electrons. It is shown that the observed change in the specific heat of electricity at the Curie point in nickel is consistent with the ferromagnetic properties.—**G. W. Brindley**: On the damping of the torsional oscillations of a sphere in a viscous medium. An expression is developed for the damping of the torsional oscillations of a sphere in a viscous medium from which the viscosity of the medium may be obtained. The expression has been tested for water, but the observed damping is found to be 5–10 per cent greater than the calculated value.—**J. Duffey**:

The electric beam discharge in argon. Electron beam phenomena at low pressures are described, and space-potential measurements obtained by use of a cold exploring electrode given. Certain parts of the discharge can be explained on the ordinary space-charge theory.—**J. E. Taylor**: Experiments on the efficiency of an electron gun. An improved type of electron gun is described in which better focusing and higher beam efficiency are obtained by interposing between the emitting filament and gun muzzle a negative screen with a small central hole. This screen has low negative potentials applied to it, and curves are given which show that maximum efficiency is attained at a certain screen potential which varies with the gas pressure. The device resembles in its action the soft three-electrode valve.—**H. M. Dawson** and **E. Spivey**: The determination of catalytic co-efficients from iso-catalytic data. Values for the coefficients which measure the catalytic activity of the non-ionised acid (k_m) and the acid anion (k_a) may be derived from the minimum reaction velocities (iso-catalytic velocities) which are observed when acetate buffers of the type $c\ CH_3CO_2H + x\ CH_3CO_2Na$, in which c is constant and x variable, are employed as catalysts for the reaction between acetone and iodine. The experimental data for series of solutions with $c = 0{\cdot}02$, $0{\cdot}1$, and $0{\cdot}5$ respectively and a $0{\cdot}75$ molar solution of sodium chloride as the reaction lead to values of $k_m = 1{\cdot}3 \times 10^{-6}$ and $k_a = 3{\cdot}3 \times 10^{-6}$ for the undissociated acid and the acetate ion. (Temperature, 25°; acetone concentration, 20 c.c. per litre.)—**J. W. Belton**: The activity coefficient of a non-electrolyte in aqueous salt solutions from solubility measurements. Measurements of the solubility of *N*-chloroacetanilide in aqueous solutions of sodium chloride, barium chloride, and magnesium sulphate show that the quantity of the anilide dissolved by 1000 grams of water is an exponential function of the ionic strength (μ) for each of these electrolytes up to $\mu = 4$.—**J. Grainger** and **Edith Angood**: The insect transmission of raspberry mosaic. The mosaic disease of raspberries has been shown to have an insect vector in a species of aphid—*Aphis rubiphila*. The mottling associated with the mosaic disease was induced in unmottled plants by caging aphids, transferred from a diseased cane, on the wild plants. Untreated controls remained healthy, so the insect is deemed to be the transmitter.—**R. D. Preston**: The structure of the wall of *Valonia ventricosa*. Recent X-ray work has shown that the cellulose wall of the plant is built up of repetitions of anhydro-glucose residues in a space lattice. This lattice has a definite orientation with reference to the surface of the wall, but the data leave open the orientation of the anhydro-glucose chains in the tangential plane. As a result of investigations with the polarising microscope, the wall of *Valonia ventricosa* is seen to consist of a mosaic of small areas, each with its own chain direction.

PARIS.

Academy of Sciences, Feb. 2.—**V. Grignard** and **L. Lapayre**: The β-enynes and β-diynes. A study of the influence on an intermediate CH_2 group of two triple bonds or one double and one triple bond. The hydrocarbons $(C_6H_5)C:C.CH_2.C:C(C_6H_5)$, $(C_6H_5).C:C.CH_2.CH:CH_2$, and $(C_5H_{11}).C:C.CH_2.CH:CH_2$ have been prepared and the acidity of the central CH_2 group examined by three methods, treatment with sodium, heating with sodium amide, and allowing to react with alkyl magnesium compounds.—**Edmond Sergent**: **A. Donatien**, **L. Parot**, and **F. Lestoquard**: The mode of transmission of North African bovine theilerosis by the tic *Hyalomma mauritanicum*. The larva nymphs of *H. mauritanicum* are infected by cattle carriers of *Theileria dispar* and, in the adult state, contaminate fresh cattle. The *Theileria dispar* infection is not hereditary in the tic.—Émile Cotton was elected *correspondant* for the section of geometry, and Seiitiro Ikeno *correspondant* for the section of botany.—**Chevalley**: The relation between the number of classes of a sub-body and that of a super-body.—**Paul Lévy**: The maximum gain in the course of a game of heads and tails.—**P. Vincensini**: A characteristic property of spiral surfaces.—**J. Doubnoff**: The tensorial characteristics of certain classes of surfaces and of their networks.—**V. Lalan**: The covariant derivatives of tensors.—**V. Romanovsky**: The zeros of stocastic matrices.—**Georges Valiron**: A general property of meromorph functions.—**Basile Demtchenko**: Some bidimensional applications of the cavitational theory of Riabouchinsky.—**Edgar Pierre Tawil**: The electricity set free in quartz crystals by bending. Detailed account of experiments on the electrical effects produced by bending quartz cylinders. The results appear to be in contradiction with the conditions of symmetry of the crystal and with the laws of piezo-electricity.—**Benjamin Jekhowsky**: A new expression of the j orientation of the great circle of asteroids.—**R. de Mallemann** and **P. Gabiano**: The magnetic rotatory power of the halogen derivatives of the saturated hydrocarbons in the gaseous state. The figures given, together with those previously published, permit the approximate calculation of the atomic magnetic rotatory powers of hydrogen, carbon, chlorine, bromine, and iodine. The rotatory powers of the ions in aqueous solutions are much greater than those of the corresponding atoms. For the three halogen elements, however, the ratio of the Verdet constants is the same, about 3 : 2.—**Er. Toporescu**: The variation in the colour of cobalt chloride solutions. At laboratory temperature, cobalt chloride in solution in methyl alcohol is rose violet, but in ethyl, *n*-propyl, *n*-butyl, and amyl alcohols it is an intense blue. On lowering the temperature the colour changes from blue to pink in each case. It is concluded that the change of colour of the solutions is a function of the dielectric constant and is caused by a change in the molecular condition of the solvent.—**Mlle. Suzanne Veil** and **L. Bull**: The microscopic and cinematographic study of Liesegang rings.—**A. Travers** and **Schnoutka**: The separation of beryllium and aluminium. A modification of Berthier's method, based on the precipitation of alumina with alkaline bisulphite.—**M. Tiffeneau** and **Mlle. Jeanne Lévy**: The benzoin condensation. The influence of the nature of the radicals on the formation of mixed benzoins.—**C. Gaudefroy**: New applications of an apparatus for measuring the angle of the optic axes.—**Roger Heim**: The phyletic connexions between the ochrospore Agarics and certain Gasteromycetes.—**Maurice Hocquette**: The influence of the substances secreted by the radicles in the course of formation on the nucleus of the neighbouring cortical cells.—**O. Munerati**: Competition between *Ustilago Tritici* and *Tilletia Tritici* in the same wheat plant.—**Mlle. M. L. Verrier**: The sensorial organs of some deep sea fish. The results of the examination of a dozen specimens collected at depths of 2900-3000 metres. It is difficult to find in these fishes a relation between the morphology of the sense organs and what is known of their mode of life and their habitat.—**Raymond-Hamet**: 3·4-Dioxyephedrin and 3·4-dioxynorephedrin.—**Tchang-Li**: A new case of embryogenic condensation in a nudibranch (*Doridopsis limbata*).—**L. Doljanski**, **J. J. Trillat**, **P. Lecomte du Noüy**, and **An. Rogozinski**: The action of X-rays on tissue cultures *in vitro*. The results of the experiments

prove conclusively that the idea of an exceptional resistance of cells cultivated *in vitro* is unfounded.—Léon Velluz and Jean Loisleur: The properties of proteocellulosic membranes.—R. Vladesco, D. Simci, and M. Popesco: A new function of the stomach. The rôle of this organ in the metabolism of urea.—C. Levaditi, P. Ravaut, P. Lépine, and Mlle. R. Schœn: The presence of a virus pathogenic for the ape in certain venereal buboes of man.

Official Publications Received.

BRITISH.

Journal of the Indian Institute of Science. Vol. 13A, Part 12: i. The Spike-Disease of *Dodonæa viscosa*, by B. N. Sastri and N. Narayana; ii. Studies in the Proteins of Indian Foodstuffs, Part 3: The Globulins of Bengal Gram (*Cicer arietinum*, Linn.) and Horse Gram (*Dolichos biflorus*), by Nuggihalli Narayana. Pp. 147-158. (Bangalore.) 12 annas.

Records of the Geological Survey of India. Vol. 63, Part 4. Pp. 379-450+li+plates 10-19. (Calcutta: Government of India, Central Publication Branch.) 2.12 rupees; 5*s*.

International Geological Congress. Compte rendu of the XV Session, South Africa, 1929. Vol. 1. Pp. xiv+314+42 plates. Vol. 2: Scientific Communications. Pp. x+688+97 plates. (Pretoria: Wallachs, Ltd.) 40*s*.

Board of Education. Report of the Consultative Committee on the Primary School. Pp. xxix+290. (London: H.M. Stationery Office.) 2*s*. 6*d*. net.

The Carnegie Trust for the Universities of Scotland. Twenty-ninth Annual Report (for the Year 1929-30) submitted by the Executive Committee to the Trustees on 11th February 1931. Pp. iv+94. (Edinburgh.)

Royal Society of Arts. Report on the Competition of Industrial Designs, 1930. Pp. 52. (London.)

Ollsgoif Na h-Eireann (The National University of Ireland). Calendar for the Year 1930. Pp. viii+298+511+222. (Dublin.)

The First Annual of the Pure Rivers Society, 1930. Pp. 60. (London.) 1*s*.

An Index to Acts of Parliament and Statutory Rules and Orders affecting the Chemical Industry. Published for the Association of British Chemical Manufacturers. Pp. 24. (Cambridge: W. Heffer and Sons, Ltd.) 2*s*. net.

FOREIGN.

United States Department of the Interior: Geological Survey. Professional Paper 100: The Coal Fields of the United States. General Introduction, by Marius R. Campbell; Ohio, by J. A. Bownocker. Pp. iv+101+9 plates. Professional Paper 160: Geologic History of the Yosemite Valley. By François E. Matthes. Pp. vi+137+52 plates. 1.10 dollars. (Washington, D.C.: Government Printing Office.)

United States Department of the Interior: Geological Survey. Water-Supply Paper 623: Surface Water Supply of the United States, 1926. Part 3: Ohio River Basin. Pp. vii+333. 50 cents. Water-Supply Paper 628: Surface Water Supply of the United States, 1926. Part 8: Western Gulf of Mexico Basins. Pp. v+207. 35 cents. Water-Supply Paper 646: Surface Water Supply of the United States, 1927. Part 6: Missouri River Basin. Pp. vi+216. 20 cents. Water-Supply Paper 647: Surface Water Supply of the United States, 1927. Part 7: Lower Mississippi River Basin. Pp. iv+98. 20 cents. Water-Supply Paper 648: Surface Water Supply of the United States, 1927. Part 8: Western Gulf of Mexico Basins. Pp. v+117. 20 cents. Water-Supply Paper 655: Surface Water Supply of Hawaii, July 1, 1926, to June 30, 1927. Pp. v+151. 25 cents. (Washington, D.C.: Government Printing Office.)

United States Department of the Interior. Fifty-first Annual Report of the Director of the Geological Survey to the Secretary of the Interior, 1930. Pp. ii+91+1 plate. (Washington, D.C.: Government Printing Office.) 15 cents.

Smithsonian Institution: United States National Museum. Report on the Progress and Condition of the United States National Museum for the Year ended June 30, 1930. Pp. ix+219. (Washington, D.C.: Government Printing Office.) 35 cents.

Institut de France: Académie des Sciences. Annuaire pour 1931. Pp. 390. (Paris: Gauthier-Villars et Cie.)

Calendario del Santuario e delle Opere di Beneficenza Cristiana di Pompei, 1931. Pp. 272. (Pompei.)

CATALOGUE.

Catalogue of Rare Books. (No. 32.) Pp. 71. (London: William H. Robinson, Ltd.)

Diary of Societies.

FRIDAY, MARCH 20.

ASSOCIATION OF ECONOMIC BIOLOGISTS (in Botany Lecture Room, Imperial College of Science and Technology), at 2.30.—Dr. A. C. Thaysen: Retrospects and Prospects of the Economic Application of Micro-biology.—H. J. Bunker: A General Review of the Microbiology of Cellulose and its Associated Compounds.

ROYAL SOCIETY OF MEDICINE (Balneology and Climatology Section), at 5.—Dr. W. Edgecombe and others: Discussion on Osteoarthritis.

LONDON SOCIETY (at Royal Society of Arts), at 5.—Lord Moynihan: Ancient Methods of Surgery.

PHYSICAL SOCIETY (at Imperial College of Science) (Annual General Meeting), at 5.—Presentation of Duddell Medal, 1930, to Sir J. Ambrose Fleming.

ROYAL SANITARY INSTITUTE (at Technical College, Lincoln), at 5.—L. O. Need and others: Discussion on Houseboats on Inland Waterways.—S. C. Baggott and others: Discussion on Refuse Collection and Disposal.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Sir Arthur Keith: Demonstration of the Anatomy and Nerve Supply of the Diaphragm.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—R. S. Allen and W. E. W. Millington: Modern Methods of raising Water from Underground Sources.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Mining Institute, Newcastle-upon-Tyne), at 6.—T. Millican: Corrosion with Reference to Boilers.

INSTITUTION OF ELECTRICAL ENGINEERS (Meter and Instrument Section) (Informal Meeting), at 6.30.—W. Lawson and others: Discussion on Should the Bottom Bearings of Meters be Oiled?—W. Holmes and others: Discussion on Are Cobalt Steel Magnets Desirable for Use as Permanent Magnets for Instruments?—Lt.-Col. K. Edgcumbe and F. Hope-Jones: Discussion on Are Synchronous Motors or Clocks More Suitable for Time Service?—J. W. Record and W. Phillips: Discussion on Are Long Scales Preferable to Short in Indicating Instruments?

SOCIETY OF DYERS AND COLOURISTS (London Section) (at Dyers' Hall, E.C.), at 6.45.—Capt. Whiteman: Spray Dyeing.

INSTITUTE OF CHEMISTRY (Manchester Section) (Annual General Meeting) (at "Manchester Ltd.", Manchester), at 7.—Prof. R. M. Caven: Lecture.

INSTITUTION OF MECHANICAL ENGINEERS (jointly with Institution of Automobile Engineers) (at Merchant Venturers' Technical College, Bristol), at 7.—Dr. J. S. Davies: An Experimental Investigation into Induction Conditions, Distribution and Turbulence in Petrol Engines.

SOCIETY OF CHEMICAL INDUSTRY (Newcastle Section) (at Armstrong College, Newcastle-upon-Tyne), at 7.30.—H. W. Howes: Pyrex Glasses, their Properties and Uses.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—W. S. Roberts: Some Token Systems of Railway Signalling.

ROYAL SOCIETY OF MEDICINE (Electro-Therapeutics Section), at 8.30.—Dr. Chalmers Watson: Radiation in Relation to Human and Animal Life.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Prof. E. N. da C. Andrade: Sound, Sand, and Smoke: New Light on Old Problems.

GEOLOGISTS' ASSOCIATION (North-East Lancashire Group) (at Technical College, Blackburn).—J. Ranson: The Structure of the Alps (Lecture).

SATURDAY, MARCH 21.

BRITISH MYCOLOGICAL SOCIETY (in Botanical Department, University College), at 11 A.M.—Miss D. Ashworth: Development of Spores in Choanophoraceæ.—Miss M. Brett: Reversible Saltation in *Stemphylium*.—P. H. Gregory: The *Fusarium* Bulb-rot of *Narcissus*.—W. M. Ware: Mushroom Growing: its Scientific and Practical Aspects.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS (Yorkshire and North Western Districts) (at College of Technology, Manchester), at 2.30.—Dorman, Long and Co., Ltd.: The Building of the New Tyne Bridge, The Building of Imperial Chemical House, and The Sydney Harbour Bridge.

MATHEMATICAL ASSOCIATION (at Bedford College), at 3.—S. Inman: Contracted Methods in Arithmetic.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Lord Rutherford: Recent Researches on the Alpha-Rays (3).

RURAL RECONSTRUCTION ASSOCIATION (at 26 Bedford Square), at 3.—R. Borlase Matthews: The Importance of Electrical Development to the Countryside.—M. Fordham: Marketing and Employment.

MONDAY, MARCH 23.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—R. T. Payne: Demonstration on Pathological Specimens Relating to Diseases of the Gall-Bladder and Extra-hepatic Biliary Passages.

INSTITUTION OF MECHANICAL ENGINEERS (Annual Meeting), at 6.45.—Short Papers.

INSTITUTION OF ELECTRICAL ENGINEERS (North-Eastern Centre) (at Armstrong College, Newcastle-upon-Tyne), at 7.

INSTITUTION OF ELECTRICAL ENGINEERS (South Midland Centre) (at Birmingham University), at 7.—J. W. Rissik and H. Rissik: Heavy-Duty Rectifiers and their Application to Traction Substations.

INSTITUTE OF FUEL (at Institution of Civil Engineers), at 7.30.—R. A. Burrows: Self-help in the Coal Industry.

BRITISH KINEMATOGRAPH SOCIETY (at Film House, Wardour Street), at 7.45.—L. Rowson: Some Aspects of Camera Work in Hollywood.

ROYAL SOCIETY OF ARTS, at 8.—Capt. A. G. D. West: The Recording and Reproducing of Sound (Cantor Lectures) (3).

ROYAL SOCIETY OF MEDICINE (Odontology Section), at 8.—Clinical Meeting.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Dr. C. Christy: Liberia in 1930.

SOCIETY OF CHEMICAL INDUSTRY (Yorkshire Section) (Annual General Meeting) (at Leeds).—H. J. Pooley and others: Discussion on the Activities of the Society.

TUESDAY, MARCH 24.

ROYAL SOCIETY OF ARTS, at 4.30.—Dominions and Colonies Meeting.

ROYAL SOCIETY OF MEDICINE (Medicine Section), at 5.—Dr. Janet Vaughan, Dr. S. C. Dyke, Dr. J. F. Wilkinson, and others: Discussion on The Value of Liver in Treatment.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Sir William Willcox: Toxic Jaundice (Lumleian Lectures) (2).

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Dr. C. D. Darlington: The Cytological Theory of Heredity and Variation (3).

EUGENICS SOCIETY (at Linnean Society), at 5.30.—W. Palin Elderton: Heredity and Insurance.

INSTITUTION OF CIVIL ENGINEERS, at 6.—G. C. Minnitt: The Washaway and Reconstruction of the Nerbudda Bridge on the Great Indian Peninsula Railway.—The late P. Allan: The George's River Bridge, New South Wales.

INSTITUTION OF ELECTRICAL ENGINEERS (London Students' Section), at 6.15.—R. Appleyard: Michael Faraday.

INSTITUTION OF ELECTRICAL ENGINEERS (North Midland Centre) (at Hotel Metropole, Leeds), at 7.—E. S. Ritter: Picture Telegraphy.

INSTITUTION OF ELECTRICAL ENGINEERING (North-Western Centre) (at Engineers' Club, Manchester), at 7.—C. E. R. Bruce: The Distribution of Energy liberated in an Oil Circuit-Breaker, with a Contribution to the Study of the Arc Temperature.

INSTITUTION OF ELECTRICAL ENGINEERS (Scottish Centre) (at North British Station Hotel, Edinburgh), at 7.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND (at 39 Elmbank Crescent, Glasgow), at 7.30.—O. Short: Design and Construction of Marine Aircraft.

QUEKETT MICROSCOPICAL CLUB (at 11 Chandos Street, W.1), at 7.30.—Gossip Meeting.

SHEFFIELD METALLURGICAL ASSOCIATION (at 198 West Street, Sheffield), at 7.30.—J. D. Hannah: Some Notes on the Selection and Examination of Materials for Driving Chain Manufacture.

INSTITUTION OF CHEMICAL ENGINEERS (at Chemical Society), at 8.—C. F. Hammond: The Concentration of Phosphoric Acid Solutions by Means of the Submerged Flame.

ROYAL ANTHROPOLOGICAL SOCIETY, at 8.30.—G. D. Hornblower: Temples and Kings of Ancient Egypt.

INSTITUTION OF ELECTRICAL ENGINEERS (East Midland Sub-Section) (at University College, Nottingham).—W. L. Webb: The Architectural Requirements of a Modern Electric Home.

INSTITUTE OF BREWING (Scottish Section) (at Caledonian Hotel, Edinburgh).—Dr. R. H. Hopkins: Physical Chemistry of the Proteins and some Applications to Brewing Problems.

INSTITUTION OF ELECTRICAL ENGINEERS (Irish Centre—Dublin).—Prof. W. Cramp: The Birth of Electrical Engineering (Faraday Lecture).

WEDNESDAY, MARCH 25.

BRITISH ASTRONOMICAL ASSOCIATION (at Sion College), at 5.

INSTITUTION OF CIVIL ENGINEERS (Students' Meeting), at 6.30.—J. M. Liddell: Recent River-wall Construction on the Thames.

INSTITUTION OF AUTOMOBILE ENGINEERS (Manchester Centre) (at Engineers' Club, Manchester), at 7.—J. E. Arrowsmith: Pressings for Automobiles.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (Tees-Side Branch) (Graduate Section) (at Cleveland Scientific and Technical Institution, Middlesbrough), at 7.—A. Brown: The Construction of the Airship Base in Ismalia.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (Graduate Section) (at Bolbec Hall, Newcastle-on-Tyne), at 7.15.—Debate: That the Present Depression in the Engineering Industry is Largely Due to Inefficient Sales Organisation

INSTITUTE OF CHEMISTRY (Belfast and District Section) (at Royal Belfast Academical Institution), at 7.30.—R. T. Shepherd: Absorption of Gases in Electrical Discharge Tubes.

ROYAL SOCIETY OF ARTS, at 8.—Prof. P. Abercrombie: The Kent Coalfields.

BRITISH PSYCHOLOGICAL SOCIETY (Medical Section) (at Medical Society of London), at 8.30.—Dr. M. F. J. Lowenfeld: A New Approach to the Problem of Psychoneurosis in Childhood.

THURSDAY, MARCH 26.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Sir William Willcox: Toxic Jaundice (Lumleian Lectures) (3).

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Prof. J. B. S. Haldane: Respiration (6).

ROYAL SOCIETY OF MEDICINE (Urology Section), at 5.30.—Prof. A. von Lichtenberg: The Principles and New Advances in Excretion Urography.

OPTICAL SOCIETY (at Imperial College of Science and Technology), at 5.30.—T. Smith: (*a*) Secondary Conjugate Surfaces; (*b*) Graphical Constructions for a Refracted Ray.—A. Whitwell: Fused Bifocal Spectacle Lenses.

INSTITUTE OF FUEL (South Wales Branch) (at South Wales Institute of Engineers, Cardiff), at 6.—Major E. Ivor David: Local Generation of Electrical Power plus the Grid.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—R. Grierson: The Electrical Heating of Buildings.

BRITISH PSYCHOLOGICAL SOCIETY (Industrial Section) (at National Institute of Industrial Psychology), at 8.—Dr. M. Drury Smith: The Idea of 'the thing as a whole' in Certain Forms of Learning.

FRIDAY, MARCH 27.

ROYAL SOCIETY FOR THE PROTECTION OF BIRDS (at Middlesex Guildhall, Westminster), at 3.—Annual Meeting.

INSTITUTION OF ELECTRICAL ENGINEERS (West Wales (Swansea) Sub-Centre) (at Electricity Offices, Swansea), at 6.

INSTITUTE OF FUEL (East Midlands Section) (at Technical College, Derby), at 7.—P. H. N. Ulander: The Power Consumption of Boiler-house Auxiliaries.

INSTITUTION OF MECHANICAL ENGINEERS (Informal Meeting), at 7.—Exhibition of Industrial Kinematograph Films.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—C. E. Prince: Light Sensitive Work in Modern Industry.

GEOLOGISTS' ASSOCIATION (in Architectural Theatre, University College), at 7.30.—Prof. L. S. Palmer: On the Pleistocene Succession of the Bristol District.—E. M. Venables: Notes on the Geology of Felpham, near Bognor Regis.

ROYAL SOCIETY OF MEDICINE (Epidemiology and State Medicine Section), at 8.—Dr. A. F. MacCallan: Trachoma: its Importance as a World-wide Disease.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Lord Rutherford: Helium and its Properties.

SATURDAY, MARCH 28.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Lord Rutherford: Recent Researches on the Alpha Rays (4).

PUBLIC LECTURES.

SATURDAY, MARCH 21.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—J. E. S. Dallas: Peasant Life in Alpine Districts.

TUESDAY, MARCH 24.

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL, at 5.15.—Dr. C. H. Andrewes: Immunity in Virus Diseases (2).

THURSDAY, MARCH 26.

BRITISH MEDICAL ASSOCIATION (Tavistock Square), at 5.15.—Prof. Major Greenwood: "Nerves" and the Public Health (Chadwick Lecture).

SATURDAY, MARCH 28.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Prof. J. R. Ainsworth Davies: Fur-bearing Animals in Canada.

CONFERENCES.

TUESDAY, MARCH 24.

CONFERENCE ON THE PLACE OF SHEEP IN MODERN FARMING (at Rothamsted Experimental Station, Harpenden), at 11.30 A.M.—Chairman: J. Egerton Quested.—Speakers: F. A. Thomson, J. R. Wood, A. Lewis, J. Joyce, Major V. S. Bland, H. Edgar, H. W. Drewitt, A. C. Hill, H. G. Miller.

SATURDAY AND MONDAY, MARCH 28 AND 30.

SOCIETY FOR EXPERIMENTAL BIOLOGY (at Edinburgh).

Saturday, March 28 (in Department of Zoology).

10 A.M. to 1 P.M.—J. Hammond: The Life of the Unfertilised Ovum.

A. J. M. Smith: The Problem of the Vitelline Membrane: (*a*) Gas Exchange and Osmotic Equilibria of the Infertile Hen's Egg.

J. Needham, M. Stephenson, and D. M. Needham: The Problem of the Vitelline Membrane: (*b*) Lactic Acid Production in the Infertile Hen's Egg.

J. Needham: The Problem of the Vitelline Membrane: (*c*) The Osmotic Properties of the Isolated Membrane.

H. O. Bull: Conditioned Responses and Salmon Smolts.

W. H. Pearsall and M. Pilling: The Physiology of Storage in the Apple.

E. C. Barton Wright: The First Sugar of Photosynthesis.

(In Department of Animal Genetics.)

2.15 to 3.45.—F. A. E. Crew and L. Mirskaia: (*a*) Genetic and Physiological Studies on the Hairless Mouse; (*b*) Observations on the Aged Male and Female Mouse.

B. P. Wiesner, P. G. Marshall, J. M. Robson, H. Taylor, and R. E. Illingworth: Recent Experiments on the Dynamics of the Sex Cycle.

3.45 to 5.30.—Demonstrations.

5.30 to 6.30.—E. Boyd: Experiments on Skin Transplantation in the Mouse.

E. M. Gilroy: The Effect of Arginine and Thyroxine on the Growth Rate of a Transplantable Tumour of the Mouse.

Monday, March 30 (in Department of Bacteriology).

10 A.M. to 12.15 P.M.—I. J. Blake: Experimental Infection of *Salmo fario* by *Bacillus salmonicida*.

A. Cunningham and T. Gibson: Recent Work on the Filterable Gonidial Stages of Bacteria.

T. J. Mackie, M. H. Finkelstein, and H. J. Gibson: The Natural Antibodies of Various Animal Species.

J. M. Alston: Analysis of Antigens on the Basis of Chemistry and Function.

M. H. Christison: Microbic Dissociation with Special Reference to the Tubercle Bacillus.

12.15 to 1.—Demonstrations.

(In Department of Zoology.)

2.15 to 3.45.—A. Walton: Gas Storage of Mammalian Spermatozoa.

A. L. Craig Bennett: Observations on the Influence of Temperature on the Breeding of Animals.

A. Graham: Temperature and *p*H Optima of Invertebrate Enzymes.

3.45 to 4.30.—Demonstrations:

4.30 to 6.—J. W. Gregor: Experimental Methods in Taxonomy.

V. E. McM. Davey: Inheritance of Colour in Certain Species of *Brassica*.

W. Black: Inheritance of Colour in the Potato Tuber.

ANNUAL MEETING.

MARCH 25, 26, AND 27.

INSTITUTION OF NAVAL ARCHITECTS (at Royal Society of Arts).

Wednesday, March 25, at 10.30 A.M.—Lord Wester Wemyss: Presidential Address.

Sir Archibald Hurd: British Sea-Power, 1900-1930.

M. F. Hay: The Maierform of Hull Construction.

Thursday, March 26, at 10.30 A.M.—Sir Charles J. O. Sanders: The Establishment of an International Load Line.

J. Foster King: International Load Lines.

L. C. Burrill: Seaworthiness of Collier Types.

At 2.30.—Prof. W. Hovgaard: A New Theory of the Distribution of Shearing Stresses in Riveted and Welded Connexions and its Application to Discontinuities in the Structure of a Ship.

F. H. Todd: Further Model Experiments on the Resistance of Mercantile Ship Forms—Coaster Vessels.

Friday, March 27, at 10.30 A.M.—Dr. H. H. Blache: The Present Position of the Diesel Engine for Marine Purposes.

H. E. Yarrow: Water Tube Boilers in Some Recent Merchant Ships with Service Results.

W. H. Howden: Some Modern Examples of Air Heaters.

At 2.30.—E. F. Spanner: Beam-Frame Connexions.