NATURE

SATURDAY, FEBRUARY 13, 1932

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Editorial and Publishing Offices:
MACMILLAN & CO., LTD.
ST. MARTIN'S STREET, LONDON, W.C.2

Editorial communications should be addressed to the Editor
Advertisements and business letters to the Publishers

Telephone Number: GERRARD 8830
Telegraphic Address: PHUSIS, WESTRAND, LONDON

No. 3250, VOL. 129]

International Co-operation

THE unanimity with which some form of deliberate planning of our national resources and of our industrial if not of our social and economic life has been suggested in technical journals of high standing and ranging over chemical industry, engineering, and the electrical and gas industries is highly significant, and is evidence of the growing realisation that a scientific age can only be safe if the powers of science are exercised with wisdom. In a speech at the annual dinner of the British Association of Chemists, Dr. E. F. Armstrong, after referring to the lack of scientific knowledge on the part of many of the world's political leaders, their opportunism and lack of definite plans, urged that chemists with other scientific workers should use their influence in industry and professionally in support of leaders who would attempt to plan the international reconstruction of the world on the basis of a definite five-year or similar plan.

It is not industry alone, however, which is insisting that problems of to-day require solution on world lines by scientific method. Even in the political sphere, the only real pieces of successful reconstruction work in post-War Europe have been schemes based on an impartial scientific analysis of the problem by the relevant experts and linked up with the appropriate action. The Austrian and Hungarian reconstruction schemes and the Greek Refugee Settlement scheme are examples of a new technique in international questions, and demonstrate beyond question the function of the technical expert in linking up knowledge and power.

The recently published report of the Basle Committee of Experts demonstrates how imperative is the need for concerted action if financial paralysis of the world is to be avoided. The dislocation at present taking place may well involve a profound change in the economic relations of one nation with another. Referring to this essential need for international co-operation, in an address on world unemployment to the Institute of International Relations at Geneva, Prof. P. H. Douglas, of the University of Chicago, pointed out that it is doubtful whether the fierce national jealousies of the world would permit the required pooling of resources and common policy, and that the issue depends upon intelligence as well as upon goodwill. There is much in the preliminary negotiations regarding the Lausanne Conference which indicates that such doubts are well founded and political prejudices still unwilling to recognise facts.

In another field we find that Major Lefebure's plea for a scientific study of the disarmament problem, and in particular for the creation of a representative scientific organisation under the League of Nations to advise on actual means for giving effect to international policy as to research on armament type, has been passed over in making preparations for the present Disarmament Conference. Further, the results of the impartial scientific investigations of many of the vexed and difficult problems related to the South Manchuria railway which have been carried out during recent years by the Institute of Pacific Relations have been brushed aside by politicians. The lack of courage, foresight, and understanding displayed in the handling of the Manchurian dispute can only be rightly assessed when we consider how much has already been provided by scientific investigations as a basis for an impartial settlement.

These recent events demonstrate that the gap between knowledge and power to which Prof. Zimmern directed attention some years ago in his brilliant study, "Learning and Leadership", has become a dangerously critical problem. Leadership has definitely weakened under the pressure of public opinion, and more and more the only hope of solving vexed problems is in entrusting the handling of them to impartial experts who are not dependent upon public opinion. The Dawes and Young Commissions were not only valuable because of the great work they did, but even more because they are typical of a new method of dealing with such questions. They applied the forces of science and expert skill and wisdom to a problem declared insoluble by governments and hopelessly vitiated by human prejudice. That their solution was only temporary and that the problem threatens to be sucked once more into the maelstrom of politics merely indicates the imperative need for extending this same technique to other international problems which react on these issues.

"Statesmen are not enough to solve the problems which arise in international affairs", General Smuts has said in a lecture on "Democracy". "The nations must become accustomed to look to the organised system of the expert report, which gives a just and impartial lead to governments and public opinion and should be regularly accepted just as judicial decisions are accepted as a matter of course. . . . Not only the discoveries of science, but the mature, sober, impartial spirit of science is what is above all else necessary for the functioning . . . of the new international system. . . . The application of the true scientific spirit to human affairs, if it were humanly possible, would mean such a reign of justice and fair play on earth as only poets have dreamt of. The cool, serious, gentle spirit of science is, above all, wanted in the storm-tossed domain of international affairs. The scientific expert . . . may prove a most valuable link in the international organisation of the future. He will function normally and dispassionately, whether international storms may rage outside; and his findings will be quietly accepted in the end, as the higher wisdom and the better way."

In the last two years a beginning has at any rate been made on some of the problems which arise out of the application of scientific method to international affairs. At a Conference of Institutions for the Scientific Study of International Relations, held in Copenhagen in June 1931, progress was made in the fundamental study of international relations, and the possibility of a systematic study of actual problems on international relations, either on the lines of the Institute of Pacific Relations or by entrusting particular researches to individual institutions, was discussed. A study of the international implications in the relations between government authority and private economic activities of individuals and groups, with special reference to the new forms of public management, control, and supervision, national or international, direct or indirect, which have grown up since the War, and the motives and policies underlying them, is contemplated at the next Conference. The possibility of a fundamental scientific study of the problem of disarmament was also suggested.

In industry, where an international outlook has become much more prevalent and the importance of scientific leadership is increasingly recognised, the possibilities visualised by General Smuts have found even more concrete expression. Sir Harry McGowan has already thrown out the suggestion of an International Council for Chemical Industry which would plan chemical industry as a world unit in regard to production, research, and development. The World Social Economic Conference held at Amsterdam last August led to definite proposals for a five-year world plan which was to be based on world solidarity, the modification of national economic policy in accordance with its effect on world economy, and the pooling of losses due to the War. The plan involves a general moratorium on all war debts and reparation payments, a series of international loans and agreements in regard to markets and production, and the establishment of a World Research Council or Planning Board to stimulate thought and action in the planning and rational organisation of the social and economic life of the world.

Were not scientific workers, as Ruskin remarked,

"still eager to add to our knowledge, rather than to use it", the new opportunities confronting them of making a vital contribution to the solution of our present difficulties would have been seized with avidity. Not only industry but also whole sections of the nation are disposed to accept the leadership of science and to adopt a well-thought-out and comprehensive scheme of national and international reconstruction based upon an authoritative and scientific analysis of the whole situation. No such scheme can, however, be produced until scientific workers are sufficiently concerned with the economic and social consequences of their work to co-operate with industrialists and others who are imbued with the scientific outlook and capable of assessing the value of scientific method and knowledge. In such co-operation there should be adequate safeguard against the neglect or abuse of human values, which Bertrand Russell fears and depicts so vividly in his sketch of scientific society and scientific government.

There are all the signs that the age of individualism and competition is passing and will be succeeded by an age of co-operation and planning on a world scale. The danger is still acute that old prejudices may delay the transition and precipitate a conflict from which the recovery of civilisation will be impossible. The existence of political prejudices in government circles should not lead us to overlook the facts that nowhere does prejudice and individualism linger more persistently than among the very scientific workers whose discoveries have made world co-operation and the renunciation of war at once inevitable and urgent. Even the difficulties and limitations on the intellectual classes and the intellectual progress of mankind directly imposed by the burden of armaments under present conditions have not sufficed to rouse general interest among scientific workers, or to induce them to make their fitting contribution in the analysis of the problem. Statesmen, indeed, need to take account of our prejudices as well as of the facts of life. Reason alone may be an incomplete guide for the control of human affairs and lead us into a tyranny which becomes intolerable to human nature because of its disregard for human values. Knowledge and leadership must be indissolubly linked if disaster is to be avoided, and to no class of the community is there a stronger challenge in the present emergency than that addressed to scientific workers to declare with a united and unequivocal voice the potentialities of science in the evolution of a better world order and the lines upon which a systematic policy can be evolved.

Horrors of the Next World War

What would be the Character of a New War? Enquiry organised by the Inter-Parliamentary Union. Pp. xviii + 411. (London: P. S. King and Son, Ltd., 1931.) 16*s*. net.

THE appearance of this volume is opportune in view of the Disarmament Conference now sitting; it contains eighteen articles contributed by eminent writers of various nations, mostly military men or university professors. Four of them are written by Frenchmen, three each by Englishmen and Germans, and others by men born in Sweden, Japan, Denmark, Switzerland, Russia, and Greece. Each author was evidently assigned a certain aspect of modern warfare, except that in some cases there are several articles on the same subject; but this plan has some disadvantages, because it was no one's duty to sum up the often conflicting conclusions, or to consider specially the fundamental nature of war. It was neglect of this last, or a too hasty generalisation from the character of a few recent conflicts, that led to the disillusions of the War of 1914–18 and of the subsequent conferences and conventions. Major Bratt and Lieut. Sergel, of Sweden, do, however, discuss the matter in the first four pages of their paper on aerial weapons and future war, and Prof. Politis (of Greece), in the final article dealing with the future of international law on warfare, says a few words on the subject.

The object of war is, of course, to defeat the enemy so effectually that he must sue for peace, and the best way to do this is to destroy a great part of his armed forces, so that he shall feel that further struggle is useless. If, however, the state of armaments be such that the powers of defence are greater than those of offence, mobile warfare becomes practically impossible, and then the invading army may make war upon the civil population, so that their miseries may induce an overwhelming desire for a cessation of hostilities. This is what happened in the Middle Ages, when the fortifications of the towns were able to withstand the assaults of hostile armies. Except in England, the sufferings of the ordinary people were terrible in every part of Europe in spite of the fact that Christian principles were professed far more then than now. In the eighteenth and nineteenth centuries artillery had reduced the value of fortresses, with the result that wars were of comparatively short duration, and were confined to the armed forces. The peoples were not affected to the same extent in this period, and a body of law on

warfare grew up in the belief that this was the normal nature of war.

In the War of 1914–18 the development of railways and other modern means of transport rendered it possible to keep so many soldiers in the field that the whole line between the conflicting nations could be fortified. So, after the first brief attempt to settle the dispute by mobile warfare, it settled down to a state of siege. In the last years of the War the improvements in aeroplanes, and the increase in their numbers, rendered it possible to attack the civilians far from the front, and this was consequently done. At the same time naval warfare degenerated into attempts at blockade, and each side tried to starve out the other—men, women, and children.

As regards the next war, some of the writers are of opinion that it would resemble the last. For example, General Réquin (of France) sums up his article on modern developments with the words: "The general military character of a future war would largely resemble that which the war of 1914–18 assumed *in its last phase*". Others, however, advance good reasons for thinking that it would be very different and probably much more terrible. General Fuller, in his article on the mechanisation of warfare, prophesies that the campaigns of the future will be settled mainly by fleets of tanks, which will be manned by comparatively small armies of highly trained men. Large masses of infantry and artillery will, nevertheless, still be required to occupy the territory conquered, or to defend their country against invading tanks. It is likely that at the commencement of hostilities neither side will have a sufficient number of these mobile forts to bring matters to a decision, but the course of events will soon cause them to be built. The side which first acquires a superiority in this arm will win.

The other important new factor will be the enormous numbers of aeroplanes. According to Bratt and Sergel, the first objective of the air force will be the corresponding force of the enemy, including his aerodromes. The second will be the enemy's land forces, upon which, however, they will not have much direct effect. If the combined action of the land and air forces does not succeed in destroying the enemy's army in a short time, part of the air force will be used to attack the enemy's centres of industry with the hope of paralysing his war effort. In this the civilians must suffer severely, even if the bombing be not carried out with the deliberate object of striking terror into them. Chemical warfare is not likely to have a decisive influence on the struggle, but it will add to its horrors. Prof. Politis quotes the following description by Prof. Noel Baker of what is likely to happen:

"Aeroplanes light fires that cannot be extinguished, setting whole districts aflame, illuminating the town, and thus making it impossible to take shelter. Bombs blow up the public buildings and the defence posts. The people are forced to take refuge in the streets. Then come the gases which, in their present form, are fatal whatever part of the body they touch. These gases, heavier than air, penetrate everywhere, into cellars, into the underground railways, permitting no escape. A bombardment of a few hours over Paris, Berlin, or London could make at least 500,000 victims."

There is no reason to think that this picture is over-drawn, and indeed there are other similar ones in the book. Nearly all the eighteen writers are of the opinion that the agreements not to use aeroplanes for bombing civilians and to renounce chemical warfare will become 'scraps of paper' when war breaks out unless their use can be prevented. But it would appear to be less difficult to stop war altogether. In the last sentence of the volume Politis says: "The real policy of peace should be to prevent war, not to humanise it". Failing such a development of public opinion that wars and armaments will become impossible, it is doubtful whether our civilisation can survive.

ARTHUR MARSHALL.

The Dynamics of Wind

Manual of Meteorology. By Sir Napier Shaw, with the assistance of Elaine Austin. Vol. 4: *Meteorological Calculus; Pressure and Wind.* (A revised edition of Part 4, 1919.) Pp. xx + 360 + xii. (Cambridge: At the University Press, 1931.) 30*s.* net.

METEOROLOGISTS the world over will be pleased that Sir Napier Shaw, the doyen of their international conferences, has been able in spite of advanced years to finish and revise, with the very efficient help of Miss Elaine Austin, his elaborate treatise on meteorology.

In meteorology elaboration is inevitable. Schoolboys have confidence in their calculations when the result is a simple number. Einstein has somewhere remarked that he was guided towards the theory of relativity partly by the notion that the universe is essentially simple. R. H. Fowler has been heard to say that of two theories the more elegant is probably the more physically correct. If such eminent physicists could be persuaded to attend to meteoro-

logy, that science would be greatly enriched; but they would probably be forced to abandon the faith that Nature is essentially simple.

This volume, which is more than twice as long as its 1919 edition, and includes many references to recent publications, bears the title "Meteorological Calculus; Pressure and Wind". Entropy also is frequently considered in its connexion with wind. The subject matter is arranged more or less in the following sequence: (1) A verbal account of the forces concerned. (2) Photographs of typical anemograph traces. (3) The general dynamical and other equations for a compressible fluid covering a rotating earth. (4) A review of the attempts that have been made to use fairly general equations. (5) The geostrophic approximation in which the pressure gradient is regarded as balanced by the Coriolis force due to the earth's rotation. (6) The effect of turbulence on the mean direction and velocity of the wind near the ground. (7) The effect of turbulence on cloud sheets. (8) Observations obtained by watching free balloons through theodolities. (9) The effect of horizontal temperature-gradient on the change of wind with height, including an elegant theory. (10) The graphic analysis of atmospheric motion. (11) A second approximation including not only the earth's rotation but also the curvature of the track on the map. (12) Cyclones and anticyclones, conventional and real, but with attention chiefly to their rotation. (13) The meeting of tropical with polar air and the resulting conversion of heat energy into motion, with the formation of cyclones. (14) Under the motto—

We look before and after
And pine for what is not—

the book ends with a retrospect of the four volumes of which it is the last.

There is in some textbooks a sort of clarity which is attained by mentioning only the simplest types of phenomena, by leaving out all inconvenient qualifications and by looking at the subject steadily from one point of view. The reader will not find that sort of clarity in this book. Instead, phenomena are considered in their actual complexity, qualifications are made prominent and the point of view wanders among the observational, mathematical, historical, administrative, and poetical aspects. Portions of information which seem to have come from one chapter have diffused into other chapters, like cumuli into the blue sky. Sir Napier "bloweth where he listeth", and it would be hard to tell whence he cometh or whither he goeth, were it not that there is a full index and a summary of the contents of the four volumes.

Sir Napier has endowed meteorology with a number of admirably descriptive and euphonious technical terms, including "geostrophic" and "tephigram". The reader should be forewarned of the queer notation "*bb*" for barometric gradient. According to V. Bjerknes an atmosphere is termed 'barotropic' if the density is either constant or *any* function of the pressure only. This term is valuable because barotropic conditions are often assumed in the older mathematical theories but seldom occur in observational data. It is regrettable that on p. 298 'barotropic' is wrongly defined by being restricted to the *special* function $pv^{\gamma} = \text{constant}$.

This volume is entitled a "calculus", but words predominate. The mathematical inquirer will find in it his observational raw material discussed by authors of wide experience, with the aid of about eighty diagrams. He will also find plenteous warnings against the approximations to which mathematicians are disposed, several important theories fully and clearly set out, and many useful references to mathematical papers old and new. But unsatisfying or mysterious summaries will probably drive him to the original works. L. F. R.

Homer's Natural History

Die homerische Tierwelt. Von Prof. Dr. Otto Körner. Zweite, für Zoologen und Philologen neubearbeitete und ergänzte Auflage. Pp. iv + 100. (München: J. F. Bergmann, 1930.) 6·60 gold marks.

THERE is no one quite like Homer to those who love him. He is so simple yet so great, so easy to understand and withal so noble, that a shadowy friendship, firm and intimate at last, grows up between us; there are few great poets who can make friends as he can with mortal men. When one does get to know Homer the friendship lasts a lifetime, and one comes to feel what Mr. Pope calls "a certain complacency in his company". Hard by my own door a scholar lives who knew his Homer by heart, every single word of him, a lifetime ago, and who has kept his friendship from youth to age; and in just the same way a certain old physician of Rostock, Prof. Otto Körner, has had Homer for a close and lifelong friend.

Fifty-two years ago, Prof. Otto Körner published, and now he has revised and enlarged, this little book on Homer's natural history; later on he wrote on Homer's and Hesiod's knowledge of the bee; and only a couple of years ago he wrote, fully and learnedly, on Homeric medicine and surgery. These cover and include Homer's

anatomy and physiology, which, as Daremberg has told us, are as admirable as those of the "Corpus Hippocraticum". In this last little book Dr. Körner told us, for example, just how, when Idomeneus had thrust his lance right into the heart of Alcathous, the last heart-beats caused the shaft to quiver: or what that Nepenthes was which Helen put into the wine-cup; or how, in August and September, the Dog-star brought malaria (πολλὸν πυρετόν) to mortal men.

Natural history never stands by itself in Homer; it lies in the background of the picture, and comes in by way of apt allusion and similitude; it is drawn from an unspoiled land, where wild life was plenteous, and wolf and eagle almost as familiar as grasshopper and nightingale. So the poet's allusions were all within the common experience of his hearers, and sometimes a phrase was enough to indicate them, and sometimes they were painted in with loving elaboration. Blind as he was, there was little Homer did not know; he knew the cuttle-fish and his suckers, and how the wolf on the mountain-side has a narrow tongue and laps like a dog. Here at random are a few of the old familiar similes.

When Sarpedon and Patroclus quarrelled they looked like two angry vultures on the ground, rushing together with flapping outspread wings;

> They cuff, they tear, they raise a screaming cry,
> The desert echoes and the rocks reply.

In a famous passage (Milton knew it well) the Trojan host is marshalled like the migrating cranes, noisily but in order; it is one of the noblest spectacles in ornithology. Penelope bids her returned but yet unrecognised husband sit a while longer and pass the evening hours; for then she sits alone and grieves—as does the nightingale. Then comes a dreadful story of the wanton handmaidens and how they met their punishment, and beat the air with twinkling feet;

> Thus on some tree, hung struggling in the air,
> The doves and thrushes flap their wings in air.

A more cheerful picture is that of the old men sitting in the gate,

> Chiefs who no more in bloody fights engage,
> But wise thro' time and narrative with age;

wisely or no, they chatter all day long—like the cicadas chirruping in the sun. The old men's garrulity, their delight in company, the thin sound, the high treble, of their old voices, their pleasure in the sunshiny day, are all told inimitably, and almost in a word. A very different picture is that of Achilles' Myrmidons on the warpath, a grim, terrific, formidable band, wolf-like, with lolling tongues, gorged but insatiate; it is the savagest and most terrible picture in all Homer.

Dr. Körner does not write eloquently or poetically; like most classical commentators his job is to look for the prose behind the poetry, but he deals very competently with his theme. There are a few stories which he does not tell. He knows that Odysseus is compared, in a certain passage, to a ram—a dubious comparison; but he does not help us (I cannot recall a single commentator who does) by explaining that this particular ram (κτίλος) is the old wise leader of the flock, *dux ovium*, trained to walk beside the shepherd as Odysseus walked by Agamemnon's side, and to be followed, trusted, pampered, and obeyed. D. W. T.

Drugs of Addiction

(1) *A Review of the Effects of Alcohol on Man.* Pp. 300. (London: Victor Gollancz, Ltd., 1931.) 8*s.* 6*d.* net.

(2) *The Alcohol Habit and its Treatment.* By Dr. Walter E. Masters. Pp. xvi + 190. (London: H. K. Lewis and Co., Ltd., 1931.) 6*s.* net.

(3) *Dangerous Drugs: the World Fight against Illicit Traffic in Narcotics.* By Arthur Woods. Pp. vii + 123. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1931.) 9*s.* net.

THESE three volumes deal with certain aspects of the medical and social problems presented by habit-forming drugs. (1) The first gives an account of the physiological and pathological effects of alcohol upon the human body and mind: it is the work of a number of different authors, and has been edited by a small private committee comprised of persons interested in the drink problem. Its aim appears to be to give a scientific account of the uses of alcohol as a food and a drug, and of the pathological results of alcoholism; chapters are devoted to the mental effects of alcohol, to its relationship to mental disorder, and to its possible racial effects. The book may be recommended as a balanced account of the subject, in which the legitimate uses of alcohol are carefully described and the effects of its abuse are neither minimised nor exaggerated.

(2) The second book is supplementary to the first. In its earlier chapters it covers much the same ground in brief, but the greater part of the book is devoted to the treatment of chronic alcoholism. Dr. Masters considers that a real cure is impossible, the criteria of cure being that the desire for the

alcoholic euphoria is abolished and the capacity for moderate indulgence regained, without the least desire for an excess. On the other hand, a number of addicts can be converted into total abstainers and in this sense cured: the rest relapse. The author includes a chapter on certain legal considerations of drunkenness.

(3) Drugs of addiction other than alcohol, morphine, cocaine, and their derivatives, are dealt with in the third book, and from an entirely different aspect. After a short account of the effects of these drugs upon the system, including the mental effects for which they are taken, the author turns to the sociological aspects of the question, including the traffic in narcotic drugs and the steps already taken under the auspices of the League of Nations to limit their manufacture and distribution. The book gives a highly interesting account of the tricks used by the traffickers in distributing the drugs: the real remedy appears to be limitation of manufacture to legitimate medical requirements, but the League has not yet persuaded all manufacturing countries to adopt vigorous measures of control. Perusal of this little book should increase the demand for firm action in those countries which have not yet adopted adequate limitation of manufacture or control of distribution.

Short Reviews

Penrose's Annual: the Process Year Book and Review of the Graphic Arts. Vol. 34, 1932. Edited by William Gamble. Pp. xv + 126 + 54 + 105 plates. (London: Percy Lund, Humphries and Co., Ltd., 1932.) 8*s*. net.

"PENROSE'S ANNUAL" is always a happy hunting-ground to anyone interested in the printing of books and pictures. This year's volume is a rich collection of work of all kinds, much of it very beautiful. Perhaps the outstanding examples are those in photogravure, both monochrome and colour. We are by this time thoroughly accustomed to the fifty-year-old 'half-tone' process, and it is therefore interesting to find that even in this process advance is being made: the successful making of blocks for half-tone reproductions in colour has depended very much on the judgment and skill of the fine etcher. The recent introduction of a special colour chart and set of dot-size samples has, however, reduced the fine etcher's work almost to a certainty—judgment and experience are largely replaced by comparison with standard dots. The general trend in the printing industry is, indeed, strongly towards standardisation of method. A new development during 1931 has been the formation of a Printing Industries Research Association. Its work so far has apparently been mainly consultative, but experimental work has begun on several problems. S. O. R.

Molds, Yeasts and Actinomycetes: a Handbook for Students of Bacteriology. By Prof. A. T. Henrici. Pp. x + 296. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1930.) 17*s*. 6*d*. net.

As our knowledge increases, the part played by fungi as distinct from bacteria in the soil, in the spoilage of food, and in disease processes in animals and in man, is becoming more recognised. A book dealing in some detail with these organisms is therefore likely to be of considerable use for reference purposes. Sufficient information is given on the morphological side to enable the more important species to be identified, whilst the chemical aspect of their behaviour is adequately considered, as well as the industrial application when such is of moment.

This book is an American production; it is well arranged and printed in clear type, and particularly well illustrated. Ample references to the literature are given at the end of each chapter.

Das Wasser in der Natur und im Dienste des Menschen. Von Dr. Hans Heinze. (Der Weg zur Natur.) Pp. xi + 164. (Freiburg im B.: Herder und Co., G.m.b.H., 1930.) 3·60 gold marks.

To discuss in any detail the occurrence of water in its many natural appearances and in its human relationships as well, would be impossible in so small a book. Therefore its eleven short chapters deal in a popular and simple manner with the more striking characteristics and influences of rain—of seas, lakes, and rivers, of snow and ice. Plant life enters the story when the fall of the leaf in autumn exemplifies the effect of a shortened water-supply, and microscopic animal life is revealed as the marvellous content of water-drops, but here the illustrations are very crude. A third of the book deals with drinking water, mineral waters, and water as a source of power, and, in connexion with each, with the apparatus by which man has harnessed them for his own purposes.

Applications of the Absolute Differential Calculus. By Prof. A. J. McConnell. Pp. xii + 318. (London, Glasgow and Bombay: Blackie and Son, Ltd., 1931.) 20*s*. net.

THIS work fills a distinct gap in the mathematical student's library by giving an account of tensor methods in their application to the more elementary problems of geometry and physics. Of the four parts into which the book is divided, the first deals in a clear and simple manner with the fundamental ideas of tensor theory. In the second part these ideas are applied to algebraic geometry. The third part introduces the absolute differential calculus proper, the differentiation of tensors, and develops the application to differential geometry. In the fourth part the author deals with applications to dynamics, hydrodynamics, electricity, and elasticity. There is a large collection of examples which greatly enhances the value of the book to the student.

Hydrogen Liquefaction Plant at the Royal Society Mond Laboratory

By Prof. P. KAPITZA, F.R.S., and Dr. J. D. COCKCROFT

IN the Royal Society Mond Laboratory which is now under construction at Cambridge, in addition to the apparatus required for producing intense magnetic fields, a plant for cryogenic work will be installed. We have developed as a first instalment of this apparatus a hydrogen liquefier which differs from existing liquefiers in that it allows hydrogen of a lower degree of purity than the normal to be used for liquefaction. We propose in this article to give a brief description of the liquefaction apparatus, and later to publish a more complete account.

As is well known, the only method used at present for the liquefaction of hydrogen is essentially the same as that employed originally by Dewar in 1898, and is based on the Joule-Thomson effect combined with a thermal regenerator. In order to obtain a positive Joule-Thomson effect for hydrogen a preliminary cooling with liquid air is required. The principal difficulty encountered in liquefying hydrogen in large quantities is due to the impurities present in the gas; unless extremely pure hydrogen is used, these impurities solidify at the temperature of liquid hydrogen and block the tubes in the regenerator and stop the circulation of the gas. The seriousness of this effect can be shown from a numerical example. The purest commercial hydrogen available in Great Britain is 99·5 per cent pure; 3·9 cubic metres of gas are required to produce 5 litres of liquid hydrogen, and the impurities—chiefly air—when solidified have a volume of about nineteen cubic centimetres. Their deposition is thus quite sufficient to block the small bore tubes of the regenerator, and special precautions have to be taken to avoid this difficulty. In the method developed by Kamerlingh Onnes at Leyden, a preliminary purification of the hydrogen to a high degree of purity is carried out, and steps are taken to save the gas after it has been used for experiments. Another method introduced by Meissner is to make a special trap in the hydrogen circulation in such a way that in it the greater part of the impurities are condensed; the liquefaction is stopped at intervals to allow the trap to be warmed by a special electrical heater and emptied.

In our liquefier we have adopted a different principle which allows us to use the apparatus continuously even with commercial hydrogen. The method is as follows: Two hydrogen circuits are used in the liquefaction process; one circulation is similar to that used in ordinary liquefiers, but is completely closed; in it about 0·7 cubic metre of purified hydrogen is compressed to 160-170 atmospheres, and after preliminary cooling in liquid nitrogen at reduced pressure passes through a regenerator spiral and then expands to normal pressure, thereby cooling down a 'condenser' to liquid hydrogen temperature, after which it returns through the regenerator to the compressor. In the second circuit we use ordinary commercial hydrogen, which is reduced to a pressure of 3-4 atmospheres by means of a reduction valve from a cylinder. This hydrogen is cooled down to the temperature of liquid nitrogen and is then passed directly into an 'exchanger' cooled by the first circuit. Since the liquefaction temperature of hydrogen at 3 atmospheres pressure is a few degrees higher than at normal pressure, it liquefies in the exchanger. The whole of the cooling down process, from the temperature of liquid nitrogen to the temperature of liquid hydrogen, takes place in the exchanger, so that all the impurities condense here and do not have a chance of being deposited in the tubes. The solidified impurities are heavier than the liquid hydrogen and remain at the bottom of the exchanger, which is large enough to retain all the impurities solidified in the course of a run.

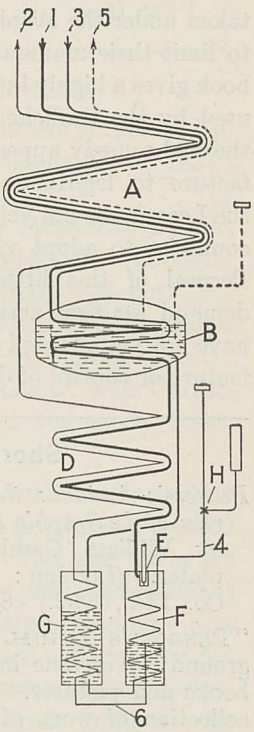


FIG. 1.

The scheme of the liquefier is shown diagrammatically in Fig. 1, and a photograph of the liquefier in Fig. 2. The hydrogen in the closed circulation enters at tube 1, passes through the regenerator spiral *A*, and enters the container *B* containing liquid nitrogen at reduced pressure, from which it passes through the second regenerator spiral *D*, and then through the expansion valve *E* to the condenser *F*, where it is partially liquefied. When the condenser *F* is about one-third full, the liquid hydrogen passes through tube 6 to a spiral which cools exchanger *G*; it then goes through the regenerator spirals *D* and *A* and passes back to the compressor through the outlet 2. The commercial hydrogen enters the tube 3 and passes only through the first regenerator circuit *A*, and the container *B*, and then passes directly into the exchanger *G*, where it meets the spiral cooled by the closed circulation and is liquefied at three atmospheres pressure. The exchanger *G* is continuously drained through the tube 4 passing through the condenser *F* as a spiral and leading to valve *H*, which controls the flow of liquid hydrogen into a Dewar receptacle. In passing through the spiral of condenser *F*, the liquid hydrogen is cooled through a few degrees from the temperature corresponding to liquefaction at three atmospheres pressure to the temperature of liquid hydrogen at atmospheric pressure. This prevents excessive evaporation when it is

drawn off into the Dewar receptacle. The exchanger G is filled with wire gauze which helps in the liquefaction. In the actual liquefier a double container is used for the liquid nitrogen. In one part the liquid nitrogen is evaporated at slightly reduced pressure and the evaporated gas passes up tube 5 of regenerator A and takes up sufficient heat to cool down the incoming hydrogen of the liquefaction circulation; in the other part the liquid nitrogen evaporates at a few centimetres pressure and passes away directly to the pump. (During a recent visit to Dr. Simon's laboratory at Berlin, we have been informed that the same principle of

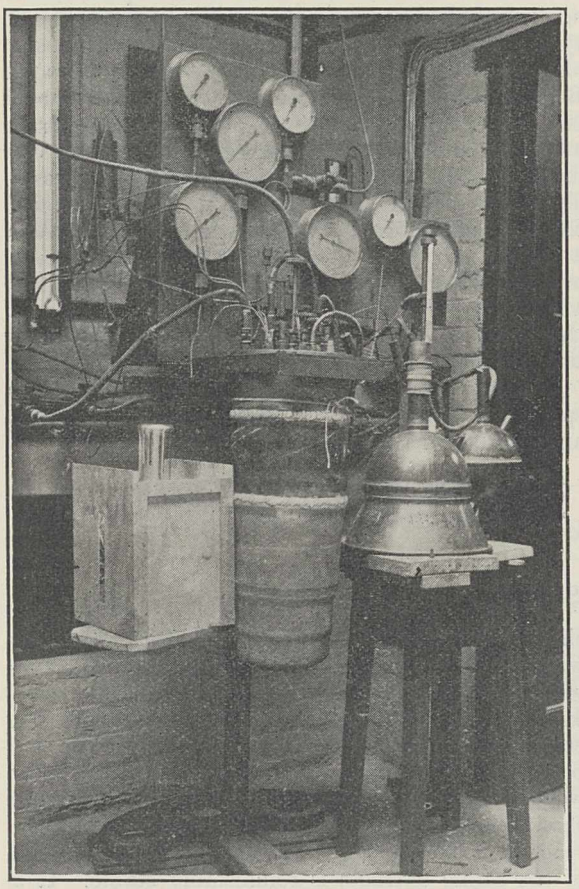


FIG. 2.

cooling hydrogen in two stages was used in his liquefier.)

The tubes used in the liquefier have a small cross-section and the gas is allowed to flow with high velocity. We find, as suggested by Meissner,[1] that the heat exchange can be calculated from Nusselt's formula.[2] From this formula it appeared that a good heat exchange could be obtained by using a high velocity of the gas, and this enabled us to reduce the length of the regenerator spirals very considerably. In our case the spiral A was about 2·5 metres long and the spiral D 5 metres. The high tensile strength of the copper-nickel alloy allows the heat capacity of the regenerator spiral to be considerably reduced. The whole apparatus is soldered into a copper vessel 26 cm. in diameter by 67 cm. high, which is then evacuated. By the use of charcoal to absorb gases given off from the metal, a good vacuum can be maintained and a high degree of thermal insulation maintained without the use of glass Dewar vessels.

The new liquefier has the considerable advantage that the rate of liquefaction can be measured continuously by a flow meter placed before the inlet of tube 3. The flow meter will also indicate the moment when the gas begins to condense. An electrical flow meter is used. The hydrogen is passed through a thin-walled copper-nickel tube 20 cm. long, which is heated in the middle by a platinum wire spiral. The cooling of this spiral depends on the rate of flow of hydrogen through the tube and is measured by its change of resistance. The spiral is made in two parts which form the two opposite arms of a Wheatstone bridge; the other two arms are also made of platinum, and are wound on the thick copper main tube, and thus are kept at the temperature of the inlet hydrogen. The apparatus is calibrated by separate experiments.

The liquefier has proved to be as efficient as ordinary existing liquefiers. The heat exchange is good, and the temperature of the return hydrogen and nitrogen at exit is only 10° below the temperature of the inlet hydrogen. 4-5 litres of liquid nitrogen are used for the initial cooling, and liquefaction starts 40-50 minutes after the beginning of the preliminary cooling. The liquefaction rate is 4 litres an hour, of which about twenty per cent is lost when the hydrogen is drawn off. The liquid nitrogen consumption is about 1·3 litres per net litre of liquid hydrogen. We normally produce 6 litres of liquid hydrogen in a single run, using commercial hydrogen, and have not up to the present had a single stoppage due to blocked tubes. The liquefier was made in our workshop by the laboratory mechanic, Mr. H. E. Pearson.

The compressor used for the work is a compact, triple stage, high speed (600 r.p.m.) machine which was specially built for us by Messrs. Reavell and Company. The detailed design was worked out by Mr. J. Hendry. Special care was taken to ensure complete freedom from leakage; the space below the cylinders is connected to the compressor suction, and the piston rods are surrounded by oil-sealed glands which are fitted with leakage indicators. At full speed the compressor capacity is 25 cubic metres of free gas per hour; at present we are using it at reduced speeds giving a delivery of 16 cubic metres per hour.

The problem of storage of liquid hydrogen has been dealt with on new lines. It is well known that owing to the small latent heat it is difficult to store liquid hydrogen in an ordinary Dewar flask for more than a day. As described by Meissner,[3] the best containers, of a capacity of 6 litres, evaporate at the rate of 15 gm. (200 c.c.) of hydrogen an hour; these containers have a specially good vacuum and silvered surfaces to prevent radiation losses, which are the most important source of loss of cold. In order to diminish these radiation losses further, we have worked out a design for a Dewar flask which has all the advantages of the

method of keeping the liquid hydrogen container immersed in liquid air, without the disadvantages and technical difficulties which occur if this method is used on a large scale. A drawing of the flask is shown in Fig. 3. It consists of a twin flask ; flask

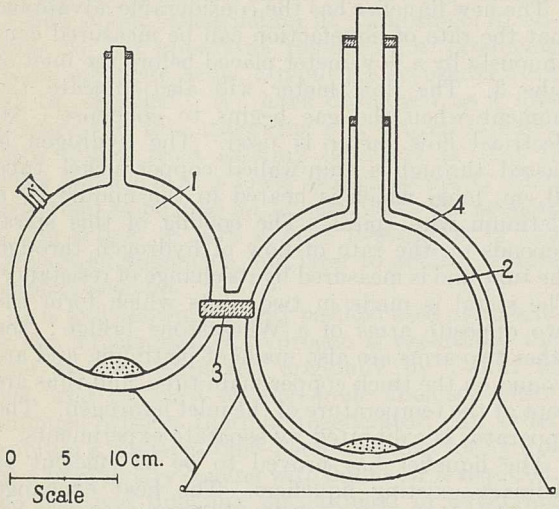


FIG. 3.

1 contains liquid air, and flask 2 liquid hydrogen. The inside of flask 1 is connected by means of a copper rod 3 to a copper shield 4 which surrounds the container of flask 2. The liquid air cools the shield 4 by thermal conductivity, and the radiation losses from the liquid hydrogen are considerably reduced. The hydrogen flask has a capacity of 5 litres and the liquid air flask holds 2 litres. The evaporation of hydrogen is about 2·5 gm. an hour, which is about seven times smaller than for ordinary flasks, and enables the liquid hydrogen not required for immediate use to remain in the flask for five days. The consumption of liquid air is about 1·7 litres per day. A picture of the flask will be seen in Fig. 2 standing beside the liquefier.

Another flask is now being constructed in which the radiation will be further reduced by silvering the inner surfaces, thereby increasing the efficiency of the flask still further. The flask was manufactured for us by Messrs. Siebe Gorman and Co., Ltd.

The remaining equipment of the Laboratory is on the usual lines, and all the known precautions against explosion are employed, flame-proof mining type motors being used for the compressor drive and all open switchgear placed in a separate room. Besides the usual precautions we have introduced one more, which consists of a standard alarm lamp as used for showing the presence of coal gas in mines. This indicator is manufactured by Messrs. The W.R. Patents, Ltd. Should a leak occur, and the concentration of hydrogen in the room reach a value of more than one per cent, the lamp operates a relay which automatically stops the machines, and throws the windows open at the bottom and the top of the rooms where the liquefier is in operation, thus providing a complete air circulation.

We were enabled to construct this plant by a special grant made by the Department of Scientific and Industrial Research.

[1] " Handbuch der Physik ", vol. 11, p. 295.
[2] Groeber, " Wärmeübertragung ", p. 84.
[3] *Z. Instrumentenkunde*, **50**, 121 ; 1930.

Diagnosis of Smallpox *

FOR adequate control of infectious disease, early and accurate diagnosis is of great importance, but clinical differentiation is not always easy in the early stages. Thus smallpox, even of the severe type, may be mistaken for chickenpox. Some years ago M. H. Gordon described a ' flocculation ' test for smallpox, which was later investigated by W. L. Burgess, J. Craigie, and W. J. Tulloch : the last two authors have now extended and amplified the earlier observations. The technique of the test is, in brief, as follows : crusts obtained from the pocks are dried and finely powdered ; the powder is extracted with ether and then with saline for some hours ; the mixture is frozen, thawed, and centrifuged to remove particulate matter. Series of dilutions of the extract are made in saline : to one antivaccinia serum is added, to the other normal rabbit serum, and both sets are incubated for about 18 hours at 45°-55° C. Flocculation occurs in the first series at high dilutions of the extract if the crusts were obtained from a case of smallpox, but is not seen in the second series to which normal rabbit serum was added.

The authors carried out an investigation of every step in the test so as to obtain the best conditions : thus it was found that more satisfactory results were obtained when the concentration of antiserum was kept constant and that of the antigen (crust extract) varied than when the converse system was employed. For the extraction of the crusts, 0·9 per cent sodium chloride solution was better than weaker concentrations and much more satisfactory than a phosphate buffer solution : in the latter the reaction shifted towards the acid side, whereas that of the saline extracts is remarkably stable. It is essential to carry out the flocculation test at about *p*H 7 : at *p*H 6 or 8 non-specific sedimentation is liable to occur. The preliminary extraction with ether removes certain substances which may obscure the test and also reduces the tendency to anomalous flocculation. It has been found further that the flocculable substance is fairly intimately connected with the euglobulin fraction of extracts although it can be to some extent separated therefrom : when the flocculable substance has been destroyed infectivity has also disappeared, but the latter can be markedly reduced without affecting the former. The purified euglobulin fraction is not very stable to heat but is fairly stable to low concentrations of phenol. It is possible to detect by the flocculation test so little as 0·0000005 gm. of purified flocculable material.

The flocculation test is positive in smallpox

* Medical Research Council. Special Report Series No. 156: Further Investigations on the Variola-Vaccinia Flocculation Reaction. By J. Craigie and W. J. Tulloch. Pp. 129. (London: H.M. Stationery Office, 1931.) 3s. net.

(mild or confluent), dermal vaccinia, neurovaccinia, or generalised vaccinia of the rabbit. Out of 195 tests on human material only three (cases of variola minor) gave apparently erroneous results: all crusts from cases of chickenpox were negative. The test is therefore specific and indicates the identity of the infecting virus of smallpox with that of vaccinia (or cowpox, the attenuated virus which is used to develop immunity to smallpox in human beings by 'vaccination'). These results also show that the secondarily infecting bacteria present in dermal material have no influence on the reaction; this conclusion was confirmed by further direct experiments. Thus it was found that crust extracts removed the flocculating property from anti-vaccinia serum, but failed to remove the staphylococcal agglutinating bodies from antistaphylococcal serum; and that absorption with suspensions of secondarily infecting bacteria had no effect on the flocculating properties of anti-vaccinia serum although such absorption rendered inert the antisera specific to the secondarily infecting organisms.

An antiserum such as is used for the flocculation test appears to exert a specific antibody action on the virus *in vitro*. After four hours incubation at 37° C. of a mixture of serum and virus the latter is inactivated or destroyed, since no lesion is produced on dermal inoculation: destruction is theoretically unlikely and probably does not actually occur since infection may be produced if inoculation is made into the rabbit's testes.

On the other hand, evidence was obtained that passive immunity to vaccinia could be produced in rabbits and guinea-pigs by the injection of anti-vaccinia serum possessing flocculating properties. The immunity of the animals was tested by dermal, testicular, and intravenous inoculation of virus: the results did not depend on the serum or strain of virus used.

As a natural sequel to the above results, attempts were made to produce immunity by the use of virus sensitised with antiserum. It was found that such a mixture, although failing to 'take' on dermal inoculation, produced, on subcutaneous injection into rabbits, a very high degree of immunity. The importance of this observation lies in the fact that it may be possible to produce immunity in human beings by this method without the risk, small though it is, of the development of the sequelæ, such as vaccinal encephalitis, which occasionally follow ordinary 'vaccination'. The theoretical objection to the use of sensitised virus is that although the antiserum may control the infection at the site of injection, it may be powerless to do so if the virus is disseminated: the authors are carrying out further investigations on this point. In any event, the results of the experiments on the production of passive immunity suggest that it might be possible to immunise smallpox contacts so that the disease would be aborted even in circumstances when vaccination might fail to prevent infection.

Obituary

MR. LOUIS BRENNAN, C.B.

BY the death of Louis Brennan on Jan. 17, at Montreux, Switzerland, Great Britain loses an inventor whose name was once very widely known. Born at Castlebar, Ireland, on Jan. 28, 1852, Brennan at an early age went to Australia, and it was while working as a watchmaker in Melbourne that he conceived the idea for a torpedo which could be fired and controlled from a fixed position.

Assisted by a member of the staff of the University of Melbourne, towards the end of the seventies of last century Brennan succeeded in arousing the interest of Government officials, and in 1880 the Admiralty appointed a committee of naval officers serving on the Australian station to report on the torpedo. Their report being favourable, Brennan was brought to England, and as the torpedo was considered very suitable for the defence of creeks and harbours, the matter was taken up by the War Office, Brennan being attached to the Royal Engineers at Chatham, and a torpedo factory being built at Gillingham. Brennan was at first given a retaining fee of £5000 and a salary of £2000. He superintended the factory for many years, and from 1896 until 1907 was retained as consulting engineer.

Like Whitehead's automobile torpedo, Brennan's machine was fish-shaped and had fins, horizontal and vertical rudders, hydrostatic depth control, and double propellers, but it was driven and controlled by two wires running over drums driven by a steam engine in the firing station and connected with other drums in the body of the torpedo.

At Gillingham, Brennan began his work on the monorail locomotive with gyroscopic stabilisers. His model, now in the Science Museum, South Kensington, was described in the technical press in 1907, and a public trial of his car took place at Gillingham on Nov. 10, 1909. The car was 40 ft. long, 10 ft. wide, and 13 ft. high, and had a wheel base of 20 ft. and a weight of 20 tons. It ran on a single rail track, which included a circular path 200 yards round, and successfully carried a party of 40 persons. It was fitted with two petrol engines driving electric generators supplying current to the driving motors, and to two large gyroscopes which preserved the balance of the car in all circumstances. Each gyroscope had a wheel weighing three-quarters of a ton, revolving at 3000 r.p.m. in a casing from which the air was exhausted. On the day of trial, owing to one of the generators being out of action, a speed of only 7 miles an hour was attained, but the designed full speed was 35 miles an hour. Brennan himself envisaged a monorail car 150 ft. long and 25 ft. wide travelling at about twice the speed of existing railway trains, but his invention did not lead to any development.

During the War, Brennan served with the Ministry of Munitions and later with the Air Ministry, and

experimented with a helicopter, but much of his work was of a confidential nature. He received the honour of C.B. in 1892, in 1906 was made a honorary member of the Royal Engineers' Institute, and in 1922 a foundation member of the National Academy of Ireland.

MR. C. J. MERFIELD

THE tragic death of Mr. Merfield as the result of a motor accident occurred on Jan. 23, 1931, but it did not become known in England until later. He was a very zealous and active worker, and undertook a large number of extensive astronomical computations. In his early career he was a surveying engineer, but even then he computed the orbits of comets in his spare time; the orbits of comets 1897 I, 1901 I, etc., were published in *Astronomische Nachrichten*. The last was a very bright southern comet; Mr. Merfield's elements, which indicate a period of 39,000 years, are accepted as definitive.

A few years later, Mr. Merfield joined the staff of the Sydney Observatory; he moved to Melbourne Observatory in 1908, and became chief assistant there in 1919, a position which he held until his death. He continued his work on comets, deducing an accurate orbit of Halley's comet from the early observations, and tracing the perturbations of the Pons-Winnecke comet for a long period, including its near approach to the earth in 1927. In his earlier years he had studied under Dr. R. T. A. Innes; it was doubtless at the suggestion of the latter that he performed the laborious task of computing the secular perturbations of Eros, Ceres, and Iris; these were published in *Astronomische Nachrichten* in 1907 and 1909.

Mr. Merfield was also interested in eclipses, and computed their circumstances in Australia and the neighbourhood; he observed the total solar eclipses of 1901, 1910, and 1911. His son, Mr. Z. A. Merfield, is the Australian representative on the Solar Eclipse Committee of the International Astronomical Union. We are indebted for many of the above details to Mr. J. A. Moroney, president of the Astronomical Society of Victoria, of which Mr. Merfield was the first president on its formation in 1922.

PROF. HOLLAND CROMPTON, formerly professor of organic chemistry at Bedford College, London, who died on Dec. 22, 1931, was born in Preston, Lancashire, on April 30, 1866. He attended school in Stuttgart and later studied chemistry under Prof. H. E. Armstrong at the City and Guilds Institute. In 1888 he was appointed lecturer and head of the Department of Chemistry at Bedford College, London, in succession to Spencer U. Pickering. He held this post until 1919, when the department was divided, and from that date until his retirement in 1927, on account of ill-health, he was head of the Department of Organic Chemistry. Crompton never enjoyed robust health, and in his later years it became steadily worse. He will be remembered by both organic and physical chemists on account of his work on acenaphthene, atomic energy and the specific heat of gases, molecular association and molecular magnitudes, osmotic pressure and the electrolytic dissociation theory.

WE regret to announce the following deaths:

Prof. Clarence L. E. Moore, professor of mathematics in the Massachusetts Institute of Technology, Cambridge, Mass., who devoted particular attention to the geometry of the sphere and circle in space, on Dec. 5, aged fifty-five years.

Prof. R. Stenhouse Williams, first director of the National Institute for Research in Dairying, Shinfield, Reading, and research professor in dairy bacteriology in the University of Reading, on Feb. 2, aged sixty years.

News and Views

Determinism Defined

SIR ARTHUR EDDINGTON'S characteristically fascinating address on "The Decline of Determinism", which we publish as our Supplement this week, will be welcomed as a clear, unequivocal statement, by a leading authority, on a question which, even among the many revolutionary aspects of the new physics, holds a pre-eminent place for importance and interest. Such a statement is the more necessary because of the almost universal tendency for discussions of determinism to be concerned at bottom with words rather than ideas, and Sir Arthur has quite properly begun by stating definitely what he means by the determinism which he holds has declined. His thorough analysis leaves little room for disagreement, but many will wonder whether he has not achieved a Pyrrhic victory by conceding to the determinist the substance of his doctrine and destroying only the shadow. "The rejection of determinism is in no sense an abdication of scientific method", and "indeterministic or secondary law . . . can be used for predicting the future as satisfactorily as primary law". In other words, Sir Arthur does not allow that the first Morning of Creation wrote what the last Dawn of Reckoning shall read, but he allows that it might have read what the last Dawn shall write. Even the most perfervid determinist will scarcely ask more. Furthermore, he acknowledges that he does not know whether Dirac, whose book "goes as deeply as anyone has yet penetrated into the fundamental structure of the physical universe", is a determinist or not. It would seem, therefore, that the determinism in question cannot be of much importance even in physics.

Physical Inference and Prediction

APPARENTLY, however, in spite of the unqualified statement concerning prediction quoted above, Sir Arthur denies that we can predict the behaviour of electrons more certainly than that of horses, and the importance, to all but the physicist, of the "decline

of determinism " therefore depends on the recognition of electrons as bodies co-equal with ordinary physical objects. To establish this he claims that since physical objects, as well as electrons and such particles, are all ' inferences ', they differ only in degree and not in kind. We must not, however, be deceived by words. Objects which we see and handle may be, as he says, as inferential as an undiscovered planet inferred from irregularities in the motion of Uranus, but the inferences are of different kinds ; otherwise, why, when a planet was seen in a different position from that inferred from the irregularities, was it *without question* preferred to the ' undiscovered ' inferential planet ? There was not even an instinctive estimate of the ' degree ' of validity to be attributed to the two ' inferences '. Unless Sir Arthur assigns to " direct observation " a status essentially different from that of rational deduction, it is difficult to see how his position can be " in no sense an abdication of scientific method ". All this, however, does not affect determinism in relation to physical objects, and it is to be hoped that Sir Arthur's plain statement will do much to remove the widespread delusion that modern physics has revealed a universe of unrestrained caprice.

Centenary of Octave Chanute

ON Feb. 18 occurs the centenary of the birth of the distinguished American engineer Octave Chanute, who by his experiments on gliding made in his later years, and by his writings on flight, gained for himself a place among the chief pioneers of aviation. Born in Paris on Feb. 18, 1832, he was the son of a professor of history who in 1838 removed to the United States to become a vice-president of the Jefferson College in Louisiana. There and in New York young Chanute attended school and, in his own words, became thoroughly Americanised. Leaving school at the age of seventeen, he entered the service of the Hudson River Railroad Company, and during the next four years gained considerable engineering experience. He next spent ten years on various railroads farther west, and from 1863 until 1867 was chief engineer of the Chicago and Alton Railroad. In 1868 he built the first bridge over the Missouri at Kansas City, in 1873 became chief engineer of the Eric Railroad, and about ten years later established himself as a consulting engineer in Kansas. He had already served on the commission of engineers which led to the building of the elevated railways of New York, and at Kansas he was responsible for the construction of the Sibley Bridge over the Missouri, and for the Mississippi Bridge at Fort Madison, Indiana. He retired to Chicago in 1889 after some forty years' work, much of which had contributed to making the railway system of the United States the most extensive in the world.

CHANUTE'S interest in flight was first aroused in 1874, but it was not until he was nearly sixty years of age that he was able to devote himself wholeheartedly to the study of the subject. In 1891 he published his first work, " Aerial Navigation ", and this was followed in 1894 by his " Progress in Flying Machines ", a work of great historical value. He had carefully examined the results of the experiments made by Otto Lilienthal in Germany, and just before that pioneer's death in 1896 had secured a Lilienthal glider and had begun his own experiments on the 90 ft. sand-hills in Dune Park, near Lake Michigan. Finding the Lilienthal machine unsafe and treacherous, Chanute built a glider with five superimposed planes, which was afterwards altered to a quadruplane and then to a triplane. From these was evolved " the famous Chanute biplane of novel and exquisite design ". One important feature introduced by Chanute was the means of moving the wings in a fore and aft direction to maintain balance, thus obviating the necessity for violent body movements. The experiments begun in June 1896 were continued until September, but after then were never resumed. An account of them was given in a paper published in the *Journal of the Society of Western Engineers* in 1897. While abandoning experiments, Chanute, although then sixty-four years of age, retained his enthusiasm for everything connected with flight, assisted and encouraged Wilbur and Orville Wright, and when an old man wrote his " Recent Progress in Aviation ". He died at Chicago on Nov. 23, 1910, at the age of seventy-eight. Chanute possessed the truly scientific spirit, and was an acute observer as well as a gifted inventor. Courageous and generous, his character caused him to be both respected and honoured.

The Earthquake in Cuba

ON Feb. 3 a series of destructive earthquakes, beginning at 2.40 A.M., ruined about one-third of the city of Santiago, at the east end of Cuba, including the cathedral and many important buildings. The number of persons killed is reported as twelve, and the number of wounded as about three hundred. The earthquake was recorded at Kew Observatory as a disturbance of moderate intensity. The first impulses arrived at 6h. 26m. 45s. A.M. (G.M.T.), and the earthquake must have occurred at 6h. 16m. The neighbourhood of Santiago has long been known as one of the most active earthquake centres in the West Indies. The city was founded in 1514, and since then there have been great destructive earthquakes in 1624, 1678, 1766 (the greatest of all Cuban earthquakes), and 1852. Though the full extent of the damage is not yet known, the recent earthquake was probably of the second order of intensity among destructive earthquakes. The Santiago earthquakes are chiefly interesting owing to the position of their centres along a well-known dislocation, nearly 1250 miles long, that skirts the southern coast of the east end of the island and forms the northern boundary of the Bartlett Trough, a depression that in one part reaches a depth of 3506 fathoms, or about four miles.

An Ancient Mexican Tomb

A VALUABLE addition to our knowledge of a little-known culture of ancient Mexico, that of the Mixtec, is promised by a recent find of which news has reached New York. In a dispatch from the *Times'* correspondent which appears in the issue of Jan. 20,

it is stated that information has been received that treasure in gold and precious stones " worth millions " has been discovered in a sealed tomb in the course of excavation, under the direction of Don Alfonso Caso, at Monte Alban, near Oaxaca. The bodies of ten Mixtec caciques were found buried under a heap of cups, urns, vases, and jars of jade, onyx, and crystal, together with personal ornaments and utensils of gold richly inlaid with turquoise. The skulls of the chieftains were encrusted with turquoise, and with them was a finely wrought mask of gold. The disorder of the funerary offerings suggests haste ; and this might have been due to the fact that the interment lies in the country of the Zapotec, with whom the Mixtec, notwithstanding their probable affinity, were frequently at war.

THE richness of the funerary offerings found at Monte Alban is fully in accord with the account given by Balboa, an early writer on the inhabitants of Mexico, of an interment in a cave—the usual type of burial chamber among the Mixtec—situated at Chalcotonga, supposed to be the gate of Paradise, in which the dead were laid out in rich garments and a number of small idols of gold, stone, and wood were placed in niches in the walls of the cave. Primary interments such as the recent discovery are supposed to have been confined to persons of high rank, the lower orders being placed in the ground for a time and their bones then collected and placed in a vase for deposit in a cave. It is suggested that the date of the burial is the fifteenth or early sixteenth century. Notwithstanding the scanty details, it is evident that this is the most imposing discovery of relics of the pre-Columbian culture of Mexico yet made. Its interest is considerably enhanced by the fact that so little relating to the Mixtec, who may in part have been of pre-Aztec strain, had been discovered previously.

Electrical Measuring Instruments

A SPECIAL exhibition of electrical measuring instruments opens at the Science Museum, South Kensington, on Feb. 13, and will remain on view until the middle of May. The exhibition illustrates the evolution of electrical measuring instruments, from the discovery of the fundamental principles on which they are based, up to the present day, and is substantially the same as the exhibition arranged by the British Electrical and Allied Manufacturers' Association and shown on the occasion of the Faraday Centenary Exhibition at the Albert Hall in September last. With the view of interesting the non-technical public, a series of simple demonstration experiments has been arranged to illustrate the various fundamental principles and their application to electrical measurement. Demonstrations will be given daily, the apparatus in some cases being a replica of that used by the original discoverer of the principle. The exhibition, which comprises about 250 exhibits, includes many original instruments, such as Kelvin's reflecting galvanometer, a resistance coil used by Wheatstone, Joule's current balance, and the coil with which Maxwell determined the ohm. Among the interesting replicas are those of Ørsted's Compass, with which the magnetic effect of an electric current was first demonstrated, Ampère's electrodynamic apparatus, the apparatus with which Ohm discovered ' Ohm's Law ', and Sturgeon's electromagnetic engine, which was the first machine to embody a commutator.

Weights and Linear Measures

IN addition, a small exhibition of weighing and linear measuring instruments will be on view in the Main Entrance Hall of the Science Museum from February until May. The exhibition illustrates briefly, by objects and photographic transparencies, progress in metrology since early times. In the very limited space available, only one form of balance has been selected for illustration—the precision or equal-armed balance ; similarly, only standard scales and micrometer development have been shown in the linear section. The exhibits include, however, the principal British Exchequer standard weights and linear measures from the time of Henry VII. (1485), excepting, of course, the current national standards. This collection, hitherto in charge of the Standards Department of the Board of Trade, has now been transferred to the Science Museum.

World's Commercial Electricity Supply

THANKS to the activities of the World Power Conference, data in connexion with the supply of electricity throughout the world are now available. It appears that in 1930 the total capacity of the electric generators used was 114 million kilowatts and that the electric units (kw.h.) generated were 304,000 million. The electricity supply industry represents the largest public utility service in the world, and the capital invested in it almost equals the capital invested in railways. If we take as our unit a 1000 million kw.h., the total output of electricity in North America was 139, of which the United States generated 121, about two-fifths of the total world output. Germany comes next with an output of 29·4, Canada with 17·8, Great Britain with 17·2, Japan with 16·3, France with 15·9, and Italy with 10·8. Owing to the world-wide industrial depression, there is a distinct slowing down of the rate of development during this period as compared with the preceding year. This is mainly due to slackness in the industralised countries of western Europe and North America. Statistics in connexion with the capacity of the dynamos installed raise the question of whether the generating equipment throughout the world has outrun the demands made on it. It is a little difficult to answer this question, but we think that when industry revives there will be an immediate demand for more electrical machines.

Northumbrian Coals

THE Fuel Research Board has just issued Paper No. 21 of the Physical and Chemical Survey of the National Coal Resources, being a report on the Yard Seam of Northumberland. The report is a very full one, and appears to be very carefully done. There is only one point to which attention may be directed. In places there is a narrow band of dirty coal at the top of the seam known locally as ' top brat ', which the report states is " sometimes known as ' roof coal '

or 'ramble'". From the wording of the report the reader might suppose that the term 'ramble' is confined to this particular coal, but as a matter of fact it is a generic term for any thin bed of shaly matter that comes down when the underlying coal is worked. Thus in the "Glossary of Terms used in the Coal Trade of Northumberland and Durham", by G. C. Greenwell, the first edition, published in 1849, defines ramble as "A thin stratum of shale, often found lying immediately above the seam of coal. It falls down, and, getting mixed with the coals, causes some trouble to the hewer, in getting it separated and cast back." Seeing that this brat, although described as dirty coal, is stated to have contained in one place as much as 69 per cent of ash, whereas one of the bands of shale contains only 46 per cent, it is obvious that this band might fairly come within Greenwell's definition. Perhaps the most interesting statement in the report is that the authors find "the coking properties of the seam to be weak, but not non-existent"; seeing that Northumbrian coals are generally supposed to be non-coking, this statement is a very important one, and leads to the inference that the Yard Seam smalls may be useful for blending with more strongly coking coals in order to produce a good metallurgical coke.

Cormorant Fishing in China

IT is sometimes said that since the neolithic age man has made no progress in domesticating wild creatures, except for the improvements made in the breeds of animals domesticated at that time. But the domestication of the cormorant in China belongs to a much more recent period. The story has been worked out in detail by Berthold Laufer of the Field Museum of Natural History, Chicago (*Field Museum Publication* 300, Anthropological Series, vol. 18, 1931). The earliest mention of the use of trained cormorants for fishing refers to Japan and dates from about A.D. 607, when, presumably, such use was unknown in China. Yet the trained cormorants of Japan are scarcely more domesticated than the English cormorants which James I. delighted to watch, and for whom he appointed a 'master of the royal cormorants'. In China the birds are completely domesticated, being bred and reared in captivity, so that they become perfectly submissive to their masters, whose commands they understand, and whom they obey with the readiness and docility of a dog. Characteristic of their domestication is the appearance amongst them of colour varieties, particularly of albinistic and pied individuals. Their eggs are always hatched by domestic fowls and not by the cormorant mother, and the young are fed on special foods until the period of their training for fishing begins, and this lasts for seven or eight months.

Investigations of Isotopes in 1931

IN the *Berichte der deutschen chemischen Gesellschaft* for January 1932 will be found a report by Prof. O. Hahn upon the progress made during the year 1931 in the investigation of isotopic forms of the elements. In a footnote it is explained that the German Chemical Society has arranged for the continuation of such reports upon this subject until such time as an international commission shall have been set up for the purpose. The present report supplements the last biennial report, published in London nearly a year ago in the *Annual Reports of the Chemical Society*. After referring to the new determination by Mecke and Childs of the relative proportions in oxygen of its isotopes, and to the desirability of retaining oxygen for the present as the standard in estimating atomic weights in spite of its complex nature, the author of the report reviews the latest developments obtained by means of the mass-spectrograph and of band spectra. Two useful tables are appended, containing respectively a list of sixty-three elements, which have hitherto been examined, together with their isotopes, and a list of no fewer than thirty-six pairs of isobars of non-radioactive elements.

American Geophysical Union

THE *Transactions of the American Geophysical Union* (published by the National Research Council) at its twelfth annual meeting, on April 30–May 1, 1931, appeared in June. This promptness, due to the able organisation of the secretary, Dr. J. A. Fleming, and to the use of direct reproduction from typescript, much enhances the value of the report. From its 227 pages geophysicists elsewhere can obtain a rapid and comprehensive view of the large amount of work in this field now being done in the United States and, to a certain extent, in Canada and Mexico. The general assembly was mainly devoted to a symposium on time-signals; most of the work of the meeting is done in the seven sectional meetings. In seismology, the papers related chiefly to the development of new or improved instruments; in meteorology, to the work of the International Polar Year; in terrestrial magnetism and electricity, including radio work, the papers were very numerous and covered a wide range of subjects; in oceanography, the reports of many institutions on their past work were the main subject of discussion; hydrology forms a separate section, and had a long and varied programme; and there were a few papers on volcanology.

Apparatus for Absorption Spectrophotometry

MESSRS. Adam Hilger, Ltd., have published an interesting booklet dealing with the outfits they supply for absorption spectrophotometry in the visible and ultra-violet regions. The most important new instrument which is described is a form of ultra-violet spectrophotometer, working on the principle of the variation of the aperture of the beam, for which the name Spekker has been registered. This has been designed primarily for use with Hilger's medium quartz spectrographs, but may be attached to any similar instrument of sufficiently great aperture. Judging by the description of the instrument, and by a specimen set of absorption photographs for benzene in hexane, this should be both highly convenient to use and accurate in the results it yields. A photoelectric outfit is also described, although not very enthusiastically, the opinion being expressed that the use of a photoelectric cell in place of the eye or a photographic record diminishes the likelihood of a number of important sources of error being recognised, so that

there is a liability that copious and apparently highly accurate results may be amassed which are actually unreliable. Other devices listed include Bay and Steiner's hydrogen discharge tubes for providing continuous ultra-violet sources of light, and also a micrometer liquid cell for studying the absorption of thin layers of liquid.

Biology in Shakespeare

IT would be indeed a difficult problem to conceive of any new point of view from which to study Shakespeare's works. In the *Scientific Monthly* for January, Prof. Fraser-Harris has made a study of the world's greatest poet and dramatist from the point of view of biology, and though the topic is not a new one—there is a public garden in Manchester where nearly all the plants, wild and cultivated, mentioned in Shakespeare are grown, and references given—the method is new, in that Prof. Fraser-Harris has aimed, not at giving a catalogue of plants and animals, but at considering a few allusions which are of distinctly physiological or psychological interest. For example, Prof. Fraser-Harris claims four participating factors in sleep — chemical, vascular, sensory, and ideational; and Shakespeare recognises two of these in the famous soliloquy of the king in "Henry IV". Although Shakespeare was a contemporary of Harvey, there is no reference in his works to blood circulation, and though one might express surprise at this, Prof. Fraser-Harris gives sufficient argument why Shakespeare was ignorant of the then new discovery. These are only two examples of how Shakespearean lines embody deep biological truths; many more, with the appropriate quotations and commentaries, are given by Prof. Fraser-Harris in his interesting article.

Veterinary Research in South Africa

WE have received the seventeenth report of the Director (Prof. P. J. du Toit) of Veterinary Services and Animal Industry, Onderstepoort, Pretoria (Union of S. Africa: Dep. of Agriculture. The Government Printer, Pretoria, 1931. 10*s*. each part). It is issued in two parts of about 425 pages each, is well produced and fully illustrated, and contains a mass of valuable material dealing with all branches of veterinary research and animal industry. Part 1 contains the parasitological matter, part 2 physiological, pathological, and industrial subjects and metabolism. Of general interest may be mentioned papers on a new and cheap method of preparing pure cystine from wool, and giving a high yield, by J. G. Louw; the good effects of sulphur on merino sheep in doses of 5 gm. from once to six times weekly, the general condition of the animals, weight, and wool yield being strikingly improved, by D. G. Steyn; and the improved quality of bacon obtained by including barley meal in the pig's ration, by D. J. Schulte and C. A. Murray.

British Lenses

WE learn from Messrs. Taylor, Taylor and Hobson, Ltd., that they have recently received a contract for no less than 350,000 lenses, totalling more than half a million glasses, for inexpensive hand cameras. Messrs. Taylor, Taylor and Hobson produce costly Cooke lenses used in some of the world's leading observatories for stellar photography, and also highly corrected Cooke lenses of large aperture for the exacting requirements of the principal cinema studios throughout Britain and the United States. It is the high degree of precision demanded by these more expensive products that has enabled the firm to design and make machinery capable of producing inexpensive lenses in such quantities and in competition with such low Continental prices as those for which the above contract has been awarded.

Eskimo Settlement in Alaska

AN expedition of the University of Pennsylvania Museum, of which Miss Frederica de Laguna is the leader, working in Alaska during the past season, reports the discovery, according to Science Service, of a prehistoric Eskimo settlement at Cook's Inlet. This area is at present inhabited by Indians, and the settlement would appear to represent the most southerly extension of Eskimo culture known. Shell heaps on the shore, some of them ten to fourteen feet in height, have been investigated. Among the relics were a number of personal ornaments, including lip plugs, beads, an ivory pendant, a carved ivory head, and a nose-pin. The objects of domestic use included a lamp, a needle-case and needles, and an ivory catch for a box. One of the most interesting relics was a mirror of slate, of which the surface showed the reflection on being damped.

Esperanto in Scientific Literature

REFERRING to the recent correspondence in NATURE on Esperanto in scientific literature, Prof. W. E. Collinson, professor of German and John Buchanan lecturer in Esperanto in the University of Liverpool, has written stating that the fullest and most extensively documented account of such writings is Section 86 of Dr. Eugen Wüster's "Internationale Sprachnormung in der Technik—besonders in der Elektrotechnik" (published with the support of the Akademie des Bauwesens, VDI-Verlag, Berlin, 1931). This work deals with the problem of the international standardisation of technical nomenclature in all its aspects, and shows the wide range of topics in which work has already appeared in Esperanto, namely, biochemistry, strength of materials, inorganic and organic chemistry, telephony and wireless, bacteriology, analytical geometry, etc.

Postponement of an International Congress

WE learn from the General Secretary, Prof. E. Moles, San Barnado 49, Madrid, that at a meeting of the Bureau of the International Union of Chemistry and the organising committee of the Ninth International Congress of Pure and Applied Chemistry held recently, it was decided to postpone the Congress indefinitely. The Congress was to have been at Madrid on April 3-10 this year, but it was felt that the present world-wide economic depression would limit seriously the usefulness of such a gathering. When conditions improve it is hoped to hold the Congress as originally arranged at Madrid.

(*Continued on p.* 241.)

Supplement to NATURE

No. 3250 FEBRUARY 13, 1932

The Decline of Determinism *

By Sir ARTHUR EDDINGTON, F.R.S.

DETERMINISM has faded out of theoretical physics. Its exit has been commented on in various ways. Some writers are incredulous, and cannot be persuaded that determinism has really been eliminated. Some think that it is only a domestic change in physics, having no reactions on general philosophic thought. Some imagine that it is a justification for miracles. Some decide cynically to wait and see if determinism fades in again.

The rejection of determinism is in no sense an abdication of scientific method; indeed it has increased the power and precision of the mathematical analysis of observed phenomena. On the other hand, I cannot agree with those who belittle the general philosophical significance of the change. The withdrawal of physical science from an attitude it has adopted consistently for more than two hundred years is not to be treated lightly; and it involves a reconsideration of our views with regard to one of the perplexing problems of our existence. In this address, I shall deal mainly with the physical universe, and say very little about mental determinism or freewill. That might well be left to those who are more accustomed to arguing about such questions, if only they could be awakened to the new situation which has arisen on the physical side. At present I can see little sign of such an awakening.

DEFINITIONS OF DETERMINISM

Let us first be sure that we agree as to what is meant by determinism. I quote three definitions or descriptions for your consideration. The first is by a mathematician (Laplace):

> We ought then to regard the present state of the universe as the effect of its antecedent state and the cause of the state that is to follow. An intelligence, who for a given instant should be acquainted with all the forces by which Nature is animated and with the several positions of the entities composing it, if, further, his intellect were vast enough to submit those data to analysis, would include in one and the same formula the movements of the largest bodies in the universe and those of the lightest atom. Nothing would be uncertain for him; the future as well as the past would be present to his eyes. The human mind in the perfection it has been able to give to astronomy affords a feeble outline of such an intelligence. . . . All its efforts in the search for truth tend to approximate without limit to the intelligence we have just imagined.

The second is by a philosopher (C. D. Broad):

> 'Determinism' is the name given to the following doctrine. Let S be any substance, ψ any characteristic, and t any moment. Suppose that S is in fact in the state σ with respect to ψ at t. Then the compound supposition that everything else in the world should have been exactly as it in fact was, and that S should have been in one of the other two alternative states with respect to ψ is an impossible one. [The three alternative states (of which σ is one) are to have the characteristic ψ, not to have it, and to be changing.]

The third is by a poet (Omar Khayyám):

> With Earth's first Clay They did the Last Man knead,
> And there of the Last Harvest sow'd the Seed:
> And the first Morning of Creation wrote
> What the Last Dawn of Reckoning shall read.

I propose to take the poet's description as my standard. Perhaps this may seem an odd choice; but there is no doubt that his words express what is in our minds when we refer to determinism. The other two definitions need to be scrutinised suspiciously; we are afraid there may be a catch in them. In saying that the physical universe as now pictured is not a universe in which "the first morning of creation wrote what the last dawn of reckoning shall read", we make it clear that the abandonment of determinism is no technical quibble, but is to be understood in the most ordinary sense of the words.

It is important to notice that all three definitions introduce the time-element. Determinism postulates not merely causes but pre-existing causes. Determinism means predetermination. Hence in any argument about determinism the dating of the alleged causes is an important matter; we must challenge them to produce their birth certificates.

* Presidential address to the Mathematical Association delivered on Jan. 4.

Ten years ago, practically every physicist of repute was, or believed himself to be, a determinist, at any rate so far as inorganic phenomena are concerned. He believed that he had come across a scheme of strictly causal law, and that it was the primary aim of science to fit as much of our experience as possible into such a scheme. The methods, definitions, and conceptions of physical science were so much bound up with this assumption of determinism that the limits (if any) of the scheme of causal law were looked upon as the ultimate limits of physical science.

To see the change that has occurred, we need only refer to a recent book which goes as deeply as anyone has yet penetrated into the fundamental structure of the physical universe, Dirac's "Quantum Mechanics". I do not know whether Dirac is a determinist or not; quite possibly he believes as firmly as ever in the existence of a scheme of strict causal law. But the significant thing is that in this book he has no occasion to refer to it. In the fullest account of what has yet been ascertained as to the way things work, causal law is not mentioned.

This is a deliberate change in the aim of theoretical physics. If the older physicist had been asked why he thought that progress consisted in fitting more and more phenomena into a deterministic scheme, his most effective reply would have been "What else is there to do?" A book such as Dirac's supplies the answer. For the new aim has been extraordinarily fruitful, and phenomena which had hitherto baffled exact mathematical treatment are now calculated and the predictions are verified by experiment. We shall see presently that indeterministic law is as useful a basis for practical predictions as deterministic law was. By all practical tests, progress along this new branch track must be recognised as a great advance in knowledge. No doubt some will say "Yes, but it is often necessary to make a detour in order to get round an obstacle. Presently we shall have passed the obstacle and be able to join the old road again." I should say rather that we are like explorers on whom at last it has dawned that there are other enterprises worth pursuing besides finding the North-West Passage; and we need not take too seriously the prophecy of the old mariners who regard these enterprises as a temporary diversion to be followed by a return to the 'true aim of geographical exploration'. But at the moment I am not concerned with prophecy and counter-prophecy; the important thing is to grasp the facts of the present situation.

Secondary Law

Let us first try to see how the new aim of physical science originated. We observe certain regularities in the course of Nature and formulate these as 'laws of Nature'. Laws may be stated positively or negatively, 'Thou shalt' or 'Thou shalt not'. For the present purpose it is most convenient to formulate them negatively. Consider the following two regularities which occur in our experience:

(*a*) We never come across equilateral triangles whose angles are unequal.

(*b*) We never come across 13 trumps in our hand at bridge.

In our ordinary outlook we explain these regularities in fundamentally different ways. We say that the first occurs because the contrary experience is *impossible*; the second occurs because the contrary experience is *too improbable*.

This distinction is entirely theoretical; there is nothing in the observations themselves to suggest to which type a particular regularity belongs. We recognise that 'impossible' and 'too improbable' can both give adequate explanation of any observed uniformity of experience, and the older theory rather haphazardly explained some uniformities one way and other uniformities the other way. In the new physics we make no such discrimination; the union obviously must be on the basis of (*b*), not (*a*). It can scarcely be supposed that there is a law of Nature which makes the holding of 13 trumps in a properly dealt hand impossible; but it *can* be supposed that our failure to find equilateral triangles with unequal angles is only because such triangles are too improbable.

We must, however, first consider the older view which distinguished type (*a*) as a special class of regularity. Accordingly, there were two types of natural law. The earth keeps revolving round the sun, because it is *impossible* it should run away. Heat flows from a hot body to a cold, because it is *too improbable* that it should flow the other way. I call the first type *primary* law, and the second type *secondary* law. The recognition of secondary law was the thin end of the wedge that ultimately cleft the deterministic scheme.

For practical purposes primary and secondary law exert equally strict control. The improbability referred to in secondary law is so enormous that failure even in an isolated case is not to be seriously contemplated. You would be utterly astounded if heat flowed from you to the fire so that you got chilled by standing in front of it, although such an occurrence is judged by physical theory to be not

impossible but improbable. Now it is axiomatic that in a deterministic scheme nothing is left to chance; a law which has the ghost of a chance of failure cannot form part of the scheme. So long as the aim of physics is to bring to light a deterministic scheme, the pursuit of secondary law is a blind alley since it leads only to probabilities. The determinist is not content with a law which prescribes that, given reasonable luck, the fire will warm me; he admits that that is the probable effect, but adds that somewhere at the base of physics there are other laws which prescribe just what the fire will do to me, luck or no luck.

To borrow an analogy from genetics, determinism is a *dominant character*. We can (and indeed must) have secondary indeterministic laws within any scheme of primary deterministic law—laws which tell us what is likely to happen but are overridden by the dominant laws which tell us what must happen. So determinism watched with equanimity the development of indeterministic law within itself. What matter? Deterministic law remains dominant. It was not foreseen that indeterministic law when fully grown might be able to stand by itself and supplant its dominant parent. There is a game called "Think of a number". After doubling, adding, and other calculations, there comes the direction "Take away the number you first thought of". We have reached that position in physics, and the time has come to take away the determinism we first thought of.

The growth of secondary law within the deterministic scheme was remarkable, and gradually sections of the subject formerly dealt with by primary law were transferred to it. There came a time when in some of the most progressive branches of physics secondary law was used exclusively. The physicist might continue to profess allegiance to primary law but he ceased to utilise it. Primary law was the gold to be kept stored in vaults; secondary law was the paper to be used for actual transactions. No one minded; it was taken for granted that the paper was backed by gold. At last came the crisis, and *physics went off the gold standard*. This happened very recently, and opinions are divided as to what the result will be. Prof. Einstein, I believe, fears disastrous inflation, and urges a return to sound currency—if we can discover it. But most theoretical physicists have begun to wonder why the now idle gold should have been credited with such magic properties. At any rate the thing has happened, and the immediate result has been a big advance in atomic physics.

We have seen that indeterministic or secondary law accounts for regularities of experience, so that it can be used for predicting the future as satisfactorily as primary law. The predictions and regularities refer to average behaviour of the vast number of particles concerned in most of our observations. When we deal with fewer particles the indeterminacy begins to be appreciable, and prediction becomes more of a gamble; until finally the behaviour of a single atom or electron has a very large measure of indeterminacy. Although some courses may be more probable than others, backing an electron to do anything is in general as uncertain as backing a horse.

It is commonly objected that our uncertainty as to what the electron will do in the future is due not to indeterminism but to ignorance. It is asserted that some character exists in the electron or its surroundings which decides its future, only physicists have not yet learned how to detect it. You will see later how I deal with this suggestion. But I would here point out that if the physicist is to take any part in the wider discussion on determinism as affecting the significance of our lives and the responsibility of our decisions, he must do so on the basis of what he has discovered, not on the basis of what it is conjectured he might discover. His first step should be to make clear that he no longer holds the position, occupied for so long, of chief advocate for determinism, and that he is *unaware* of any deterministic law in the physical universe. He steps aside and leaves it to others—philosophers, psychologists, theologians—to come forward and show, if they can, that they have found indications of determinism in some other way.* If no one comes forward, the hypothesis of determinism presumably drops; and the question whether physics is actually antagonistic to it scarcely arises. It is no use looking for an opposer until there is a proposer in the field.

Inferential Knowledge

It is now necessary to examine rather closely the nature of our knowledge of the physical universe.

All our knowledge of physical objects is by inference. We have no means of getting into direct contact with them; but they emit and scatter light waves, and they are the source of pressures transmitted through adjacent material. They are like broadcasting stations that send out signals which

* With the view of learning what might be said from the philosophical side against the abandonment of determinism, I took part in a symposium of the Aristotelian Society and Mind Association in July 1931. Indeterminists were strongly represented, but unfortunately there were no determinists in the symposium, and apparently none in the audience which discussed it. I can scarcely suppose that determinist philosophers are extinct, but it may be left to their colleagues to deal with them.

we can receive. At one stage of the transmission the signals pass along nerves within our bodies. Ultimately visual, tactual, and other sensations are provoked in the mind. It is from these remote effects that we have to argue back to the properties of the physical object at the far end of the chain of transmission. The image which arises in the mind is not the physical object, though it is a source of information about the physical object; to confuse the mental object with the physical object is to confuse the clue with the criminal. Life would be impossible if there were no kind of correspondence between the external world and the picture of it in our minds; and natural selection (reinforced where necessary by the selective activity of the Lunacy Commissioners) has seen to it that the correspondence is sufficient for practical needs. But we cannot rely on the correspondence, and in physics we do not accept any detail of the picture unless it is confirmed by more exact methods of inference.

The external world of physics is thus a universe populated with *inferences*. The inferences differ in degree and not in kind. Familiar objects which I handle are just as much inferential as a remote star which I infer from a faint image on a photographic plate, or an 'undiscovered' planet inferred from irregularities in the motion of Uranus. It is sometimes asserted that electrons are essentially more hypothetical than stars. There is no ground for such a distinction. By an instrument called a Geiger counter, electrons may be counted one by one as an observer counts one by one the stars in the sky. In each case the actual counting depends on a remote indication of the physical object. Erroneous properties may be attributed to the electron by fallacious or insufficiently grounded inference, so that we may have a totally wrong impression of what it is we are counting; but the same is equally true of the stars.

In the universe of inferences, past, present, and future appear simultaneously, and it requires scientific analysis to sort them out. By a certain rule of inference, namely, the law of gravitation, we infer the present or past existence of a dark companion to a star; by an application of the same rule of inference we infer the existence on Aug. 11, 1999, of a configuration of the sun, earth, and moon, which corresponds to a total eclipse of the sun. The shadow of the moon on Cornwall in 1999 is already in the universe of inference. It will not change its status when the year 1999 arrives and the eclipse is observed; we shall merely substitute one method of inferring the shadow for another. The shadow will always be an inference. I am speaking of the object or condition in the external world which is called a shadow; our perception of darkness is not the physical shadow, but is one of the possible clues from which its existence can be inferred.

Of particular importance to the problem of determinism are our inferences about the past. Strictly speaking, our direct inferences from sight, sound, touch, all relate to a time slightly antecedent; but often the lag is more considerable. Suppose that we wish to discover the constitution of a certain salt. We put it in a test-tube, apply certain reagents, and ultimately reach the conclusion that it *was* silver nitrate. It is no longer silver nitrate after our treatment of it. This is an example of retrospective inference: the property which we infer is not that of 'being X' but of 'having been X'.

We noted at the outset that in considering determinism the alleged causes must be challenged to produce their birth certificates so that we may know whether they really were pre-existing. Retrospective inference is particularly dangerous in this connexion because it involves antedating a certificate. The experiment above mentioned certifies the chemical constitution of a substance, but the date we write on the certificate is earlier than the date of the experiment. The antedating is often quite legitimate; but that makes the practice all the more dangerous, it lulls us into a feeling of security.

Retrospective Characters

To show how retrospective inference might be abused, suppose that there were no way of learning the chemical constitution of a substance without destroying it. By hypothesis a chemist would never know until after his experiment what substance he had been handling, so that the result of every experiment he performed would be entirely unforeseen. Must he then admit that the laws of chemistry are chaotic? A man of resource would override such a trifling obstacle. If he were discreet enough never to say beforehand what his experiment was going to demonstrate, he might give edifying lectures on the uniformity of Nature. He puts a lighted match in a cylinder of gas, and the gas burns. "There you see that hydrogen is inflammable." Or the match goes out. "That proves that nitrogen does not support combustion." Or it burns more brightly. "Evidently oxygen feeds combustion." "How do you know it was oxygen?" "By retrospective inference from the fact that the match burned more brightly." And so the experimenter passes from cylinder to cylinder; the

match sometimes behaves one way and sometimes another, thereby beautifully demonstrating the uniformity of Nature and the determinism of chemical law! It would be unkind to ask how the match must behave in order to indicate indeterminism.

If by retrospective inference we infer characters at an earlier date, and then say that those characters invariably produce at a future date the manifestation from which we inferred them, we are working in a circle. The connexion is not causation but definition, and we are not prophets but tautologists. We must not mix up the genuine achievements of scientific prediction with this kind of charlatanry, or the observed uniformities of Nature with those so easily invented by our imaginary lecturer. It is easily seen that to avoid vicious circles we must abolish purely retrospective characteristics—those which are never found as existing but always as having existed. If they do not manifest themselves until the moment that they cease to exist, they can never be used for prediction except by those who prophesy after the event.

Chemical constitution is not a retrospective character, though it is often inferred retrospectively. The fact that silver nitrate can be bought and sold shows that there is a property of *being* silver nitrate as well as of *having been* silver nitrate. Apart from special methods of determining the constitution or properties of a substance without destroying it, there is one general method widely applicable. We divide the specimen into two parts, analyse one part (destroying it if necessary), and show that its constitution *has been X*; then it is usually a fair inference that the constitution of the other part *is X*. It is sometimes argued that in this way a character inferable retrospectively must always be also inferable contemporaneously; if that were true, it would remove all danger of using retrospective inference to invent fictitious characters as causes of the events observed. Actually the danger arises just at the point where the method of sampling breaks down, namely, when we are concerned with characteristics supposed to distinguish one individual atom from another atom of the same substance; for the individual atom cannot be divided into two samples, one to analyse and one to preserve. Let us take an example:

It is known that potassium consists of two kinds of atoms, one kind being radioactive and the other inert. Let us call the two kinds Kα and Kβ. If we observe that a particular atom bursts in the radioactive manner, we shall infer that it was a Kα atom. Can we say that the explosion was predetermined by the fact that it was a Kα and not a Kβ atom? On the information stated there is no justification at all; Kα is merely an antedated label which we attach to the atom when we see that it has burst. We can always do that, however undetermined the event may be which occasions the label. Actually, however, there is more information which shows that the burst is not undetermined. Potassium is found to consist of two isotopes of atomic weights 39 and 41; and it is believed that 41 is the radioactive kind, 39 being inert. It is possible to separate the two isotopes and to pick out atoms known to be K^{41}. Thus, K^{41} is a contemporaneous character, and can legitimately predetermine the subsequent radioactive outburst; it replaces Kα which was a retrospective character.

So much for the fact of outburst; now consider the time of outburst. Nothing is known as to the time when a particular K^{41} atom will burst except that it will probably be within the next thousand million years. If, however, we observe that it bursts at a time t, we can ascribe to the atom the retrospective character K^t, meaning that it had (all along) the property that it was going to burst at time t. Now, according to modern physics, the character K^t is not manifested in any way—is not even represented in our mathematical description of the atom—until the time t when the burst occurs and the character K^t, having finished its job, disappears. In these circumstances K^t is not a predetermining cause. Our retrospective labels and characters add nothing to the plain observational fact that the burst occurred without warning at the moment t; they are merely devices for ringing a change on the tenses.

The time of break-up of a radioactive atom is an example of extreme indeterminism; but it must be understood that, according to current theory, all future events are indeterminate in greater or lesser degree, and differ only in the margin of uncertainty. When the uncertainty is below our limits of measurement, the event is looked upon as practically determinate; determinacy in this sense is relative to the refinement of our measurements. A being accustomed to time on the cosmic scale, who was not particular to a few hundred million years or so, might regard the time of break-up of the radioactive atom as practically determinate. There is one unified system of secondary law throughout physics and a continuous gradation from phenomena predictable with overwhelming probability to phenomena which are altogether indeterminate.

Criticism of Indeterminism

In saying that there is no contemporaneous characteristic of the radioactive atom determining the date at which it is going to break up, we mean that in the picture of the atom as drawn in present-day physics no such characteristic appears; the atom which will break up in 1960 and the atom which will break up in the year 150,000 are drawn precisely alike. But, it will be said, surely that only means that the characteristic is one which physics has not yet discovered; in due time it will be found and inserted in the picture either of the atom or its environment. If such indeterminacy were exceptional, that would be the natural conclusion, and we should have no objection to accepting such an explanation as a likely way out of a difficulty. But the radioactive atom was not brought forward as a difficulty; it was brought forward as a favourable illustration of that which applies in greater or lesser degree to all kinds of phenomena. There is a difference between explaining away an exception and explaining away a rule.

The persistent critic continues: "You are evading the point. I contend that there are characteristics unknown to you which completely predetermine not only the time of break-up of the radioactive atom but also all physical phenomena. How do you know there are not? You are not omniscient."

The curious thing is that the determinist who takes this line is under the illusion that he is adopting a more modest attitude in regard to our scientific knowledge than the indeterminist. The indeterminist is accused of claiming omniscience. I will not make quite the same countercharge against the determinist; but surely it is only a man who thinks himself *nearly* omniscient who would have the audacity to start enumerating all the things which (it occurs to him) might exist without his knowing it. I am so far from omniscient that my list would contain innumerable entries. If it is any satisfaction to the critic, my list does include deterministic characters—along with Martian irrigation works, ectoplasm, etc.—as things which might exist unknown to me.

It must be realised that determinism is a positive assertion about the behaviour of the universe. It is not sufficient for the determinist to claim that there is no fatal objection to his assertion; he must produce some reason for making it. I do not say he must prove it, for in science we are ready to believe things on evidence falling short of strict proof. If no reason for asserting it can be given, it collapses as an idle speculation. It is astonishing that even scientific writers on determinism advocate it without thinking it necessary to say anything in its favour, merely pointing out that the new physical theories do not actually disprove determinism. If that really represents the status of determinism, no reputable scientific journal would waste space over it. Conjectures put forward on slender evidence are the curse of science; a conjecture for which there is no evidence at all is an outrage. So far as the physical universe is concerned, determinism appears to explain nothing; for in the modern books which go farthest into the theory of the phenomena no use is made of it.

Indeterminism is not a positive assertion. I am an indeterminist in the same way that I am an anti-moon-is-made-of-green-cheese-ist. That does not mean that I especially identify myself with the doctrine that the moon is *not* made of green cheese. Whether or not the green cheese lunar theory can be reconciled with modern astronomy is scarcely worth inquiring; the main point is that green-cheesism, like determinism, is a conjecture that we have no reason for entertaining. Undisprovable hypotheses of that kind can be invented *ad lib.*

Principle of Uncertainty

The mathematical treatment of an indeterminate universe does not differ much in form from the older treatment designed for a determinate universe. The equations of wave mechanics used in the new theory are not different in principle from those of hydrodynamics. The fact is that, since an algebraic symbol can be used to represent either a known or an unknown quantity, we can symbolise a definitely predetermined future or an unknown future in the same way. The difference is that whereas in the older formulæ every symbol was theoretically determinable by observation, in the present theory there occur symbols the values of which are not assignable by observation.

Hence, if we use the equations to predict, say, the future velocity of an electron, the result will be an expression containing, besides known symbols, a number of undeterminable symbols. The latter make the prediction indeterminate. (I am not here trying to prove or explain the indeterminacy of the future; I am only stating how we adapt our mathematical technique to deal with an indeterminate future.) The indeterminate symbols can often (or perhaps always) be expressed as unknown phase-angles. When a large number of phase-angles are involved, we may assume in averaging that they are uniformly distributed from 0° to

360°, and so obtain predictions which could only fail if there has been an unlikely coincidence of phase-angles. That is the secret of all our successful prophecies; the unknowns are not eliminated by determinate equations but by averaging.

There is a very remarkable relation between the determined and the undetermined symbols, which is known as Heisenberg's Principle of Uncertainty. The symbols are paired together, every determined symbol having an undetermined symbol as partner. I think that this regularity makes it clear that the occurrence of undetermined symbols in the mathematical theory is not a blemish; it gives a special kind of symmetry to the whole picture. The theoretical limitation on our power of predicting the future is seen to be systematic, and it cannot be confused with other casual limitations due to our lack of skill.

Let us consider an isolated system. It is part of a universe of inference, and all that can be embodied in it must be capable of being inferred from the influence which it broadcasts over its surroundings. Whenever we state the properties of a body in terms of physical quantities, we are imparting knowledge as to the response of various external indicators to its presence and nothing more. A knowledge of the response of all kinds of objects would determine completely its relation to its environment, leaving only its unget-at-able inner nature, which is outside the scope of physics. Thus, if the system is really isolated so that it has no interaction with its surroundings, it has no properties belonging to physics, but only an inner nature which is beyond physics. So we must modify the conditions a little. Let it for a moment have some interaction with the world exterior to it; the interaction starts a train of influences which may reach an observer; he can from this one signal draw an inference about the system, that is, fix the value of one of the symbols describing the system or fix one equation for determining their values. To determine more symbols there must be further interactions, one for each new value fixed. It might seem that in time we could fix all the symbols in this way, so that there would be no undetermined symbols in the description of the system. But it must be remembered that the interaction which disturbs the external world by a signal also reacts on the system.

There is thus a double consequence; the interaction starts a signal through the external world informing us that the value of a certain symbol p in the system is p_1, and at the same time it alters to an indeterminable extent the value of another symbol q in the system. If we had learned from former signals that the value of q was q_1, our knowledge will cease to apply, and we must start again to find the new value of q. Presently there may be another interaction which tells us that q is now q_2; but the same interaction knocks out the value p_1 and we no longer know p. It is of the utmost importance for prediction that a paired symbol and not the inferred symbol is upset by the interaction. If the signal taught us that at the moment of interaction p was p_1, but that p had been upset by the interaction and the value no longer held good, we should never have anything but retrospective knowledge—like the chemistry lecturer to whom I referred above. Actually we can have contemporaneous knowledge of the values of half the symbols, but never more than half. We are like the comedian picking up parcels who, each time he picks up one, drops another.

There are various possible transformations of the symbols and the condition can be expressed in another way. Instead of two paired symbols, one wholly known and the other wholly unknown, we can take two symbols each of which is known with some uncertainty; then the rule is that the product of the two uncertainties is fixed. Any interaction which reduces the uncertainty of determination of one increases the uncertainty of the other. For example, the position and velocity of an electron are paired in this way. We can fix the position with a probable error of 0·001 mm. and the velocity with a probable error of about 1 km. per sec.; or we can fix the position to 0·0001 mm. and the velocity to 10 km. per sec.; and so on. We divide the uncertainty how we like, but we cannot get rid of it. If current theory is right, this is not a question of lack of skill or a perverse delight of Nature in tantalising us; for the uncertainty is actually embodied in the theoretical picture of the electron; so that if we describe something as having exact position and velocity we cannot be describing an electron.

If we divide the uncertainty in position and velocity at time t_1 in the most favourable way, we find that the predicted position of the electron one second later (at time t_2) is uncertain to about five centimetres. That represents the extent to which the future position is not predetermined by anything existing one second earlier. If the position at time t_2 always remained uncertain to this extent, there would be no failure of determinism, for the thing we had failed to predict (exact position at time t_2) would be meaningless. But *when the second has elapsed* we can measure the position of the electron to 0·001 mm. or even more closely, as

already stated. This accurate position is not predetermined; we have to wait until the time arrives and then measure it. It may be recalled that the new knowledge is acquired at a price. Along with our rough knowledge of position (to 5 cm.) we had a fair knowledge of the velocity; but when we acquire more accurate knowledge of the position, the velocity goes back into extreme uncertainty.

We might spend a long while admiring the detailed working of this cunning arrangement by which we are prevented from finding out more than we ought to know. But I do not think we should look on these as Nature's devices to prevent us from seeing too far into the future. They are the devices of the mathematician who has to protect himself from making impossible predictions. It commonly happens that when we ask silly questions, mathematical theory does not directly refuse to answer but gives a non-committal answer like $\frac{0}{0}$, out of which we cannot wring any definite meaning. Similarly, when we ask where the electron will be to-morrow, mathematical theory does not give the straightforward answer, "It is impossible to say, because it is not yet decided", because that is beyond the resources of an algebraic vocabulary. It gives us an ordinary formula of x's and y's, but makes sure that we cannot possibly find out what the formula means—until to-morrow.

Mental Indeterminism

I have, perhaps fortunately, left myself no time to discuss the effect of indeterminacy in the physical universe on our general outlook. I will content myself with stating in summary form the points which seem to arise.

(1) If the whole physical universe is deterministic, mental decisions (or at least *effective* mental decisions) must also be predetermined. For if it is predetermined in the physical world (to which your body belongs) that there will be a pipe between your lips on Jan. 1, the result of your mental struggle on Dec. 31 as to whether you will give up smoking in the New Year is evidently predetermined. The new physics thus opens the door to indeterminacy of mental phenomena, whereas the old deterministic physics bolted and barred it completely.

(2) The door is opened slightly, but apparently the opening is not wide enough; for according to analogy with inorganic physical systems, we should expect the indeterminacy of human movements to be quantitatively insignificant. In some way we must transfer to human movements the wide indeterminacy characteristic of atoms, instead of the almost negligible indeterminacy manifested by inorganic systems of comparable scale. I think this difficulty is not insuperable, but it must not be underrated.

(3) Although we may be uncertain as to the intermediate steps, we can scarcely doubt what is the final answer. If the atom has indeterminacy, surely the human mind will have an equal indeterminacy; for we can scarcely accept a theory which makes out the mind to be more mechanistic than the atom.

(4) Is the human will really more free if its decisions are swayed by new factors born from moment to moment than if they are the outcome solely of heredity, training, and other predetermining causes? On such questions as these we have nothing new to say. Argument will no doubt continue 'about it and about'. But it seems to me that there is a far more important aspect of indeterminacy. It makes it possible that the mind is not utterly deceived as to the mode in which its decisions are reached. On the deterministic theory of the physical world, my hand in writing this address is guided in a predetermined course according to the equations of mathematical physics; my mind is unessential—a busybody who invents an irrelevant story about a scientific argument as an explanation of what my hand is doing—an explanation which can only be described as a downright lie. If it is true that the mind is so utterly deceived in the story it weaves round our human actions, I do not see where we are to obtain our confidence in the story it tells of the physical universe.

Physics is becoming difficult to understand. First relativity theory, then quantum theory, then wave mechanics have transformed the universe, making it seem ever more fantastic to our minds. Perhaps the end is not yet. But there is another side to this transformation. Naïve realism, materialism, the mechanistic hypothesis were simple; but I think that it was only by closing our eyes to the essential nature of experience, relating as it does to the reactions of a conscious being, that they could be made to seem credible. These revolutions of scientific thought are clearing up the deeper contradictions between life and theoretical knowledge, and the latest phase with its release from determinism marks a great step onwards. I will even venture to say that in the present theory of the physical universe we have at last reached something which a reasonable man might almost believe.

Printed in Great Britain by R. & R. Clark, Limited, *Edinburgh.*

Announcements

THE annual Sir John Rhŷs Memorial Lecture of the British Academy will be delivered on Feb. 17 by Prof. H. J. Fleure, professor of geography in the University of Manchester, who will take as his subject "Archæology and Folk-Tradition".

THE ninety-first annual general meeting of the Chemical Society will be held in Glasgow on March 18, under the presidency of Prof. G. G. Henderson, regius professor of chemistry in the University of Glasgow, who will take as the subject for his address "The Publication of Chemical Literature". This will be the first official visit of the Society to Scotland.

THE Right Hon. Lord Plender; Mr. Bertram S. Thomas, Arabian explorer and orientalist; and the Rev. A. T. P. Williams, headmaster of Winchester College, have been elected members of the Athenæum under the provisions of Rule II. of the Club, which empowers the annual election by the committee of a certain number of persons of distinguished eminence in science, literature, the arts, or for public services.

THE Langley Prize, which is usually awarded every three years for the best paper submitted by officers of the West African Medical Service—whether on the active or retired list—has been awarded by the London School of Hygiene and Tropical Medicine in equal shares for Dr. E. C. Smith's paper "A Dermatological Atlas of Nigeria" and for Dr. Hope Gill's paper "Diagnostic Methods in Human Trypanosomiasis".

THE following appointments in the Colonial Agricultural Service have recently been made by the Secretary of State for the Colonies: Mr. G. E. Bodkin, Government entomologist, Palestine, to be director of agriculture, Mauritius; Mr. A. S. Thomas, economic botanist, Gold Coast, to be assistant botanist, Uganda; Mr. J. E. P. Booth, to be agricultural officer, Kenya; Mr. R. E. T. Hobbs, to be agricultural officer, Kenya; Mr. W. T. Dalgarno, to be agricultural instructor, Bahamas; Mr. J. C. Eyre, to be district agricultural officer, Tanganyika Territory.

IN view of the present situation, and the recent appointment of Dr. C. P. Blacker as general secretary of the Eugenics Society, the salaried appointment of Mrs. C. B. S. Hodson will terminate next August. Mrs. Hodson is to continue to work in close association with the Society as a member of the council, and so secure the continuation of the eugenic work already begun in different parts of Great Britain. This arrangement leaves unaffected Mrs. Hodson's position as honorary administrative secretary to the International Federation of Eugenic Organizations, and she retains her place on the Committee for Legalising Eugenic Sterilization.

OWING to the closing of Chillingham Castle, Northumberland, efforts are being made to keep together the famous herd of wild cattle which is believed to have roamed in the castle enclosure since the thirteenth century. It is announced in the *Times* of Feb. 8 that the Zoological Society of London has undertaken to contribute £100 a year for seven years if a lease at £500 a year for that period is granted to three trustees nominated by the Society. The remainder of the £500 a year is to be provided by public subscription. The trustees are Lord Grey of Fallodon, Mr. Hugh S. Gladstone, and Sir Peter Chalmers Mitchell. A public appeal will shortly be made.

WE have received List No. 23, January 1932, of Eastman Organic Chemicals, from the Eastman Kodak Co., Rochester, New York. This contains the names of a large number of special chemicals already available, and also several additions, the specification of which occupies six pages of the catalogue. The prices of all the chemicals are given, and a valuable feature of the list is the inclusion of the physical constants of nearly all the chemicals.

MR. C. R. S. MANDERS suggests in a letter to the Editor that a magnetic field might produce a marked change in the specific inductive capacity of substance. The suggestion is fairly obvious, but no references are given to work upon the subject; and as Mr. Manders gives no address, we are unable to return his letter.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—An assistant secretary of the University of Birmingham—The Secretary, University, Birmingham (Feb. 15). A senior assistant hydrometric engineer in the Civil Engineering Department of the Electricity Supply Board of the Irish Free State—The Secretary, Electricity Supply Board, 60-62 Upper Mount Street, Dublin (Feb. 17). A senior assistant in the library of the University College of Hull—The Registrar, University College, Hull (Feb. 19). An assistant master, mainly for chemistry and physics, at the Acton Technical College—The Principal, Technical College, Acton (Feb. 20). A junior lecturer in the Department of Pathology, University of Liverpool—The Professor of Pathology, University, Liverpool (Feb. 21). A lecturer in engineering at the Wigan and District Mining and Technical College—The Principal, Wigan and District Mining and Technical College, Wigan (Feb. 22). A head of the Department of Industrial and Fine Art, Loughborough College—The Registrar, Loughborough College, Loughborough (Feb. 26). A principal of the Westminster Technical Institute—The Education Officer (T.1), County Hall, Westminster Bridge, S.E.1 (Feb. 29). A lecturer in experimental pathology and assistant director of cancer research in the University of Leeds—The Registrar, University, Leeds (March 1). A professor of anatomy in the University of Lucknow—The Registrar, Lucknow University, Lucknow, India (March 30). A part-time lecturer in Sinhalese at the School of Oriental Studies—The Secretary, School of Oriental Studies, Finsbury Circus, E.C.2 (April 20). A lecturer in English in the University of Hong Kong—The Secretary, Universities Bureau of the British Empire, 88A Gower Street, W.C.1 (April 30). A professor of agricultural botany in the University of Reading—The Registrar, University, Reading.

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.*]

Artificial Production of Fast Protons

A HIGH potential laboratory has been developed at the Cavendish Laboratory for the study of the properties of high speed positive ions. The potential from a high voltage transformer is rectified and multiplied four times by a special arrangement of rectifiers and condensers, giving a working steady potential of 800 kilovolts. Currents of the order of a milliampere may be obtained at a potential constant to 1-2 per cent.

Protons from a discharge in hydrogen are directed down the axis of two glass cylinders 14 in. in diameter and 36 in. long, and accelerated by the steady potentials of the rectifier. They are then passed into an experimental chamber at atmospheric pressure through a mica window having a stopping power of about 1 mm. air equivalent. Luminescence of the air can easily be observed.

The ranges of the protons in air and hydrogen have been measured using a fluorescent screen as a detector. The range in air at S.T.P. of a proton having a velocity of 10^9 cm./sec. is found to be 8·2 mm., whilst the corresponding range for hydrogen is 3·2 cm. The observed ranges support the general conclusions of Blackett on the relative ranges of protons and α-particles, although the absolute values of the ranges are lower for both gases. The ranges and stopping power will be measured more accurately by an ionisation method.

The maximum energy of the protons produced up to the present has been 710 kilovolts with a velocity of $1{\cdot}16 \times 10^9$ cm./sec. and a corresponding range in air of 13·5 mm. at S.T.P. We do not anticipate any difficulty in working up to 800 kilovolts with our present apparatus.

J. D. COCKCROFT.
E. T. S. WALTON.

Cavendish Laboratory,
Cambridge, Feb. 2.

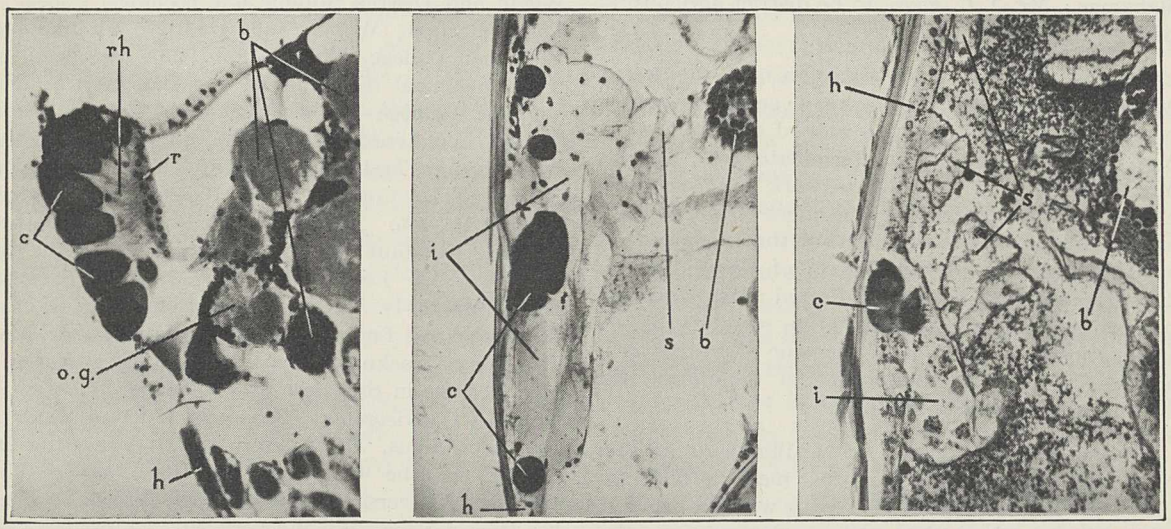
Structure of Normal and Mutant Eyes in *Gammarus chevreuxi*

NUMEROUS mutant types of eye have been found in *Gammarus chevreuxi* by Sexton, and their genetic behaviour analysed by her and various other workers.[1] We have now examined the structure of some of these, and find certain surprising results. The normal or wild type eye is of the usual structure,[2] with hypodermis, crystalline cones, rhabdomes, and retinular cells. Prolongations of the retinular cells surround the rhabdomes and the base of the cones, and are the seat of both the red and black pigments of the eye. In addition, between the rhabdomes and cones are to be seen interstitial cells, which contain the interommatidial white pigment characteristic of so many gammarids.

The albino mutant is a simple recessive (*ccW*, as against *CW* for wild type, where *C-c* is the gene controlling the appearance of red and black pigments). It lacks *both* red and black pigment; the eye is irregular and entirely white. Sections (Fig. 1) show that the crystalline cones are present, but irregularly spheroidal and situated at various levels instead of conical and at a constant level; the bulk of the eye consists of interstitial cells, much hypertrophied in size and possibly increased in number. There is a total absence of retinula. No connexion exists between eye and brain, and the optic ganglion also appears to be absent. In most cases the eye in section is of a fairly regular flattened cake-like shape, but sometimes irregular prolongations of the interstitial tissue extend somewhat into the interior of the head.

The colourless eye is the product of two recessive genes (*ccww* in genetic constitution, where *W-w* is the gene controlling the appearance of white pigment). In sections, colourless eyes are in general similar to albino eyes. But the crystalline cones are usually increased in number, and may be irregularly fused with each other in a very peculiar way, while the interstitial tissue may be somewhat reduced, and may show signs of degeneration (abnormally staining nuclei, and crystalline inclusions in the cells).

In both albino and colourless eyes a peculiar large-celled spongy tissue pervades much of the head; the origin and nature of this has not yet been satisfactorily determined. It might possibly be a modification of the connective tissue found surrounding



A B C

FIG. 1.—Sections of normal and mutant eyes of *Gammarus chevreuxi*. A, normal eye; B, albino eye; C, colourless eye. *b*, brain; *c*, crystalline cones; *h*, hypodermis, with overlying cuticle; *i*, interstitial tissue; *o.g.*, optic ganglion; *r*, retinular tissue; *rh*, position of rhabdomes (and interstitial cells in normal); *s*, spongy tissue (in mutants).

the brain in the wild type, or may be derived from the abnormal development of retinular and optic ganglion rudiments.

The main differentiation of the eye occurs from about two days before hatching (at 23° C.) to a little after hatching. Sections taken of embryos during this period show that from the outset the cells which should give rise to retinular tissue are very much reduced in number in albinos; the first origin of interstitial tissue appears to take place at the usual time.

It is hoped to make a further analysis of the earlier developmental processes leading to the mutant types. Meanwhile the work has already explained one genetic puzzle. In most known cases of mendelising colour-characters, single mutations affect the chemical processes leading to the formation of one particular kind of pigment. But the *cc* mutation of *Gammarus* affects two wholly different kinds of pigment, a red lipochrome and a black melanin. This is now seen to be due to the fact that both these pigments are normally present only in the retinular cells, and that the primary effect of the *c* gene is to prevent the development of these cells.

As the albino and colourless eyes are so defective in structure, and have no connexion with the brain, they would be expected to be functionless. This appears to be the case. Normal *Gammarus* are slightly negatively phototropic: albino specimens appear not to be. Owing to the constant restless swimming of this species only statistical results can be obtained. A long tube containing twenty specimens was illuminated from one end and the number of specimens in the half nearer the light counted at regular intervals. In a series of experiments the average percentage of animals in the half nearer the source of light was 35 per cent for wild type, but 45 per cent for albinos. Further, from experiments in which the tube is reversed at regular intervals, it seems that there is a true directive effect of light in the wild type, but that the distribution of the albinos is a matter of chance; for the number of specimens in the half nearer the light is *always* less than 50 per cent in the wild type, while in the albinos it alternates regularly between less than 50 per cent and more than 50 per cent. It is very difficult to make good sections from the adult eyes: we have to thank Dr. H. Eltringham, who has special experience with arthropods, for kindly cutting the adult specimens here described and illustrated.

JULIAN S. HUXLEY.
A. WOLSKY.

King's College, London,
Dec. 22.

[1] References in Allen and Sexton, *J. Genet.*, **9**, 347; 1920. Sexton, Clark, and Spooner, *J. Mar. Biol. Ass.*, **17**, 189; 1930. Huxley, *Brit. J. Exp. Biol.*, **1**, 79; 1923.
[2] Schatz, E., *Z. wiss. Zool.*, **135**, 539; 1929.

Photochemical Reaction between Hydrogen and Chlorine in the Presence of Oxygen

IT has been generally assumed that the hydrogen chloride produced when a mixture of hydrogen and chlorine is illuminated has no effect on the velocity of reaction. If, however, the magnitudes of the Draper effects are considered for two reaction mixtures which do not differ in hydrogen, chlorine, and oxygen concentrations, but only in the circumstance that one (*a*) contains no hydrogen chloride, and the other (*b*) an amount of hydrogen chloride equal, say, to that of the concentration of chlorine, then the magnitude of the Draper effect in (*a*) can be observed to fall off very rapidly on illumination, while that of (*b*) shows no such rapid initial fall but is always smaller than the initial value in the case of (*a*). Indications of a rapid initial fall in reaction velocity in mixtures containing initially no hydrogen chloride can indeed be recognised in the 'velocity coefficients' given by several workers; for example, by Bodenstein and Dux.[1]

Experiment has shown that the presence of hydrogen chloride (in the reaction vessel) does markedly inhibit the reaction. The apparatus employed was essentially that described by Griffiths and Norrish.[2] With the plane-faced quartz and glass reaction vessels here used, chlorine at 50 mm. pressure absorbed about fifty per cent of the incident light of wave-length 365 $\mu\mu$. By calibrating the light absorption against concentration, concentrations of chlorine in this region could be determined from the absorption with an accuracy greater than 0·5 mm. This was the method of measurement of hydrogen chloride formation, quantum efficiency figures in general being repeatable with an accuracy within 5 per cent.

Some experimental figures for two wave-lengths are given graphically in Fig. 1, which refers always to an average pressure of chlorine and hydrogen equal

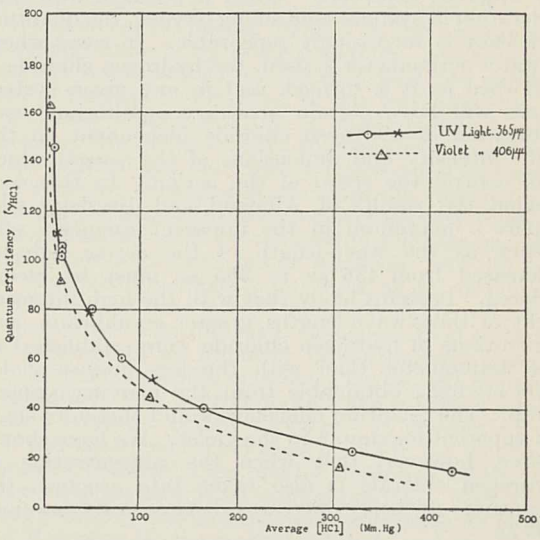


FIG. 1.

to 44 mm. each, and a pressure of oxygen equal to 50 mm. The two curves are directly comparable, and the efficiency of the formation per absorbed quantum is always less for light of wave-length 406 $\mu\mu$ than for light of 365 $\mu\mu$.

Experiments with low oxygen concentration (<1·0 mm.) gave similar results. Our results to date are closely reproduced by the following expression for the quantum efficiency of hydrogen chloride formation:

$$\gamma_{HCl} = \frac{k_1}{(O_2)([HCl] + k_2)}.$$

This formula has been established so far over a range of pressure of oxygen of from 10 mm. to 350 mm., and for a ten-fold variation in light intensity; it will, however, be somewhat amplified when we have completed the study of the separate variation of the hydrogen and chlorine concentrations, which up to the present have been kept constant.

That the inhibiting action of hydrogen chloride as it accumulates is quite specific and unconnected with any 'inert gas effect' is evidenced by the fact that the addition of nitrogen has no action on the course of the reaction. The results were always repeatable to within 5 per cent, whether the hydrogen chloride was added to the system, or allowed to accumulate

as the result of reaction, and no irregularities were ever observed such as would indicate the presence of chance inhibitors.

A series of experiments was also carried out with phosphorus pentoxide in the reaction vessel. Provided the phosphorus pentoxide was dry, no absorption of hydrogen chloride occurred, and the pressure change, measured by a Bourdon gauge, indicated the rate of formation of water. The quantum efficiency of water formation rose from a low value (<0·2) to a value not greater than 1 as the hydrogen chloride concentration was increased from zero to 400 mm. (oxygen, 50 mm.; average chlorine and average hydrogen, 44 mm.). The chains of the hydrogen chlorine reaction must therefore be broken by the hydrogen chloride and oxygen, acting jointly, possibly in a ternary collision of H, O_2, and HCl, with water as one of the products.

The inhibiting action of hydrogen chloride puts a new complexion on the kinetics of the hydrogen–chlorine reaction. Neglect of this factor is responsible for the diverse quantum efficiencies recorded by different observers. When it is taken into consideration in systems containing oxygen, the quantum efficiency is surprisingly repeatable. In cases where a water actinometer is used, the hydrogen chloride is absorbed as it is formed, and in any given system there will be a certain arbitrary equilibrium concentration of hydrogen chloride (dependent on the light intensity and dimensions of the vessel) which will control the speed of the action. In this connexion the results of Allmand and Beesley,[3] who report a maximum in the apparent quantum efficiency as the wave-length of the active light is decreased from 436 $\mu\mu$ to 365 $\mu\mu$, must be reconsidered. It seems likely that with the high intensity light of these wave-lengths, greater equilibrium concentrations of hydrogen chloride were established in the actinometer than with the less intense violet (406 $\mu\mu$) light obtainable from the mercury vapour lamp. The quantum efficiency would therefore show an apparent maximum in the violet. We have shown above, however, that when the concentration of hydrogen chloride is also taken into account, the quantum efficiency increases between 406 $\mu\mu$ and 365 $\mu\mu$.

MOWBRAY RITCHIE.
R. G. W. NORRISH.

Department of Physical Chemistry,
University, Cambridge,
Jan. 8.

[1] *Z. physik. Chem.*, **85**, 316; 1913.
[2] *Proc. Roy. Soc.*, A., **130**, 591; 1931.
[3] *J. Chem. Soc.*, 2709; 1930.

Co-ordination of Hydrogen in Associated Liquids

SIMONS and Bouknight [1] have described measurements of the density and surface tension of hydrogen fluoride at various temperatures; but in their discussion, although they calculate the Eötvös constant, they do not give any value of the parachor.

Using their results and the measurements of the vapour density made by Simons and Hildebrand in 1924, the parachor can be evaluated, and the figures show that it increases from 34·2 at −80° to 35·8 at 19·5°.

This result is an interesting addition to those quoted by Sidgwick and Bayliss [2] in support of their ideas on the co-ordination of hydrogen in associated liquids. The 'theoretical' parachor for hydrogen fluoride is 42·8, so that the actual value shows a defect nearly equal to the 7·2 which should characterise a liquid associating to double molecules; moreover, the defect decreases steadily with rise of temperature, as was to have been anticipated, suggesting a decrease in the extent of the association.

It is noteworthy that if, on the other hand, single electron bonds are assumed in order to avoid the expansion of the electronic group of the hydrogen atom implied above, then a smaller degree of association would be required to account for the defect observed—a smaller one than perhaps seems likely from other considerations.

J. C. SPEAKMAN.

Chemistry Department,
University, Sheffield,
Jan. 27.

[1] *J. Amer. Chem. Soc.*, **53**, 129; 1932.
[2] *J. Chem. Soc.*, 2027; 1930.

Oxygen and Everest

THERE are one or two statements in Sir Leonard Hill's letter, and that of Dr. Greene, in NATURE of Jan. 16, which I think require comment and correction.

It would surely be difficult to instance a more cogent demonstration of the possibilities of high altitude acclimatisation than that provided by the recent Bavarian expedition to Kangchenjunga. The climbing party were able by reason of slow upward progress, consequent upon the extreme difficulties of the lower part of their route, to attain such a degree of acclimatisation that at approximately 26,000 ft. they were ascending, in deep snow, at the remarkable rate of 650 ft. per hour. Sir Leonard altogether fails to appreciate what this performance means; and the fact that the party were carrying very heavy loads makes it all the more remarkable. Sir Leonard elsewhere emphasises that one (though only one) of the party had heart-trouble. In the circumstances, was it not surprising that more of the party had not heart- and other organic troubles? We find, however, that their later strenuous activities in the region, during their return, suggest neither deterioration nor organic degeneration as a result of their amazing efforts on the mountain.

Sir Leonard is incorrect in his statement that the climbers on the last Everest expedition, who persevered at 28,000 ft., all came to grief! As mentioned in my last letter, neither Norton nor Somervell were in the pink of condition when they commenced their climb, and Norton, who persisted to about 28,126 ft., turned back because of the lateness of the hour and his anxiety to regain Somervell before nightfall. He had by no means come to grief, and could have persevered higher, in spite of eye trouble consequent upon having removed his snow-goggles earlier in the day: the strength of re-radiated light at these altitudes, even from bare rock surfaces, had been sufficient to affect his unprotected eyes. Moreover, none of the 1924 Everest party can be said to have suffered, like the animals of the experiment, degenerate organic change from their sojourn at high altitudes. On leaving Tibet they were mostly in excellent condition, and no one has suffered any after-effects.

It may well be that the cats, rats, and mice, etc., of Dr. Campbell's experiment showed no interest in continuing to live at the low oxygen partial pressures to which they were subjected, in spite of being brought gradually to such pressures. But the latter process quite obviously did not constitute acclimatisation, nor was it at all likely to do so considering the complete inactivity meanwhile of the subjects of the experiment.

Whatever analogies, however, on a physical basis may be drawn, such experiments on animals entirely leave out of account the psychological factor so germane to all man's higher activities: the will

to climb higher, the exhilaration of possible success, apart from the accompanying stimulating effects of environment in this case. These psychological factors have their physical reactions, which are quite certainly of a beneficial character.

As we have said before, however, though acclimatisation to the highest altitudes should be aimed at, and has, we believe, already been demonstrated to 27,000 ft. in 1924, we recommended at that time that light oxygen equipment be available in case of need on another Everest attempt. Whether such apparatus be used by the actual climbing party on emergency, or merely for experimental purposes on an attached 'physiological squad', it would be desirable to have it as light in weight as possible. If the metallurgist could be prevailed upon to devise an even lighter alloy for gas cylinders than the 'Vibrac' steel used in 1924, it might so materially reduce the total load and bulk of the apparatus as to warrant belief in its possible practicability, either on the final portion of the ascent or for use in high camps by unacclimatised persons, or even during spells of intense cold: under the latter conditions some persons have reported experiencing benefit from breathing oxygen—but this is only another symptom of inadequate acclimatisation.

Liquid oxygen apparatus has been considered, but has been ruled out as quite impracticable for mountain use.

Finally, Sir Leonard queries whether the failure of the hill-peoples of the Himalaya to go above 18,000 ft. during the summer months may not be on account of realisation of the physiological injuriousness of doing so. The alternative, of the upper limit of pastures, must surely here be the deciding factor, since, so far as I am aware, no grazing beyond that sufficient for the burhel and other mountain sheep exists above 18,000 ft. in any part of the Himalaya. Most plants, even of the simple alpine types, cease at 18,000-19,000 ft., although on Everest and Kangchenjunga hardy species of *Arenaria* and *Delphinium* have been found as high as 20,400 ft. and 20,600 ft. respectively: but these are exceptions.

N. E. ODELL.

Clare College,
Cambridge, Jan. 31.

Atomic Weight of Fluorine

WE find ourselves in complete agreement with Prof. Moles's remarks [1] on the values which can be obtained for the atomic weight of fluorine from the limiting densities of silicon fluoride. It appears to us, however, that when two theoretically calculated compressibility coefficients applied to the same data lead to values of the atomic weight of fluorine of 19·09 and 18·995 respectively, little significance can be attached to either of these values.

We would like to point out that the work of McAdam and Smith [2] on the ratio of sodium chloride to sodium fluoride gave an atomic weight of 19·015 when their weighings were not corrected to a vacuum. These results have been corrected to a vacuum by Smith and Haagen (*Carnegie Institution Report*, No. 267, p. 47), who thus find the value 19·009 (not 19·019 as stated by Prof. Moles).

In our original letter we did not bring forward the work of Smith and Haagen (*Carnegie Institution Report*, No. 267) on the ratio of borax to various other salts, as these lead to an atomic weight of boron differing considerably from the accepted value. If, however, we assume that the cross ratios from their mean values give trustworthy data for finding the atomic weight of fluorine, we obtain the following results (taking Na = 22·997, C = 12·005, N = 14·009, S = 32·068):

Cross ratio.	At. Wt. Fluorine.
NaF : NaCl	19·001
2 NaF : Na_2SO_4	19·003
NaF : $NaNO_3$	19·004
2 NaF : Na_2CO_3	19·008
Average	19·004

Smith and Haagen themselves give an average value F = 19·005. Combining Smith and Haagen's results with those of McAdam and Smith, it seems likely that, as we suggested in our original communication, the stoicheiometric atomic weight of fluorine lies in the neighbourhood of 19·01 rather than 19·00

Prof. Moles has suggested that our preliminary higher value for the atomic weight (19·01) is due to the gas, which was made by Collie's method, consisting of a constant boiling mixture of methyl fluoride and 2 per cent of methane. This could not explain the divergence, since if the presence of such an amount of methane were assumed, the pure methyl fluoride would give an atomic weight of the order of 19·4.

We have read Gonzalez' paper [3] on the preparation of methyl fluoride by Collie's method. We consider that his results afford no evidence that the purified methyl fluoride he prepared in this way consisted of a constant boiling mixture of methyl fluoride and methane. He did not detect the presence of methane in his purified gas, but merely inferred the existence of a constant boiling mixture, since the vapour pressure and the density of his gas disagreed with those of methyl fluoride made by the methyl sulphate and the silver fluoride–methyl iodide methods. We did not use these latter methods in our work, as we considered it unlikely that pure methyl fluoride could be obtained in these ways. By diffusion, Gonzalez failed to show the presence of an impurity in the purified methyl fluoride made by Collie's method. On general grounds, it is unlikely that methyl fluoride and methane would form a constant boiling mixture. It appears to us that the experimental evidence points to the fact that Gonzalez obtained pure methyl fluoride, whilst the other methods lead to an impure product. This view is supported by the fact that the gases made by Moles and Batuecas by the methyl sulphate and the silver fluoride–methyl iodide methods show differences in mean density amounting to 0·006 in the atomic weight of fluorine.

In conclusion, we may say that we do not wish to stress unduly from our own preliminary experiments a value of F = 19·01 rather than F = 19·00 for the atomic weight of fluorine. The chemical evidence at present available, however, appears to point to the higher value. The question can only be settled by further experiment.

H. S. PATTERSON.
W. CAWOOD.
R. WHYTLAW-GRAY.

University, Leeds,
Jan. 20.

[1] NATURE, **128**, 966, Dec. 5, 1931.
[2] *J. Amer. Chem. Soc.*, **34**, 592; 1912.
[3] *Annales. Soc. esp. Fis. Quim.*, **20**, 539; 1922.

Structure and Development of Temperature Inversions in the Atmosphere

MESSRS. Mal, Basu, and Desai have discussed recently [1] the subject of temperature inversions with dry air above them. Their forthcoming publication, in which the effects of turbulence and radiation are discussed quantitatively, will be welcomed by meteorologists. It is, however, scarcely correct to

state that the present view implies that the discontinuity of temperature develops before that of humidity. Some years ago I discussed the prevailing ideas on this subject [2] (including a paragraph drawn up in collaboration with the late M. A. Giblett), and the view taken was rather that the discontinuities of humidity and of temperature develop simultaneously under the influence of a number of factors. The main emphasis was placed on the adiabatic warming of slowly descending air, with its greater effect on dry than on cloudy air, and on turbulence up to a limit which becomes gradually lower and more sharply defined. The importance of radiation in increasing existing discontinuities was mentioned, though no doubt it ought to have been stressed more strongly.

Adiabatic warming gives a simple explanation of both the warmth and dryness above the inversions, and, moreover, these inversions are found when descending air is to be inferred from divergence in the horizontal air motion. They are by no means always present above horizontal cloud-sheets. In the particular circumstances mentioned by Messrs. Mal, Basu, and Desai, namely, in the region between a retreating cyclone and an advancing anticyclone, the observed change leading up to the inversion is normally a rise of temperature above the inversion level rather than a fall below it.

If we consider inversions in all conditions, we find that a rise of temperature above and a fall below are about equally important on the average, but it must be remembered that the air is normally in motion. In the rare cases when the air is stagnant the observed changes of upper air temperature and humidity are small. It is essential to distinguish between changes at one place and changes in a given mass of air. In the case of an inversion it is sometimes necessary to follow the air masses above and below it on separate tracks, but this is by no means always so, since many anticyclonic inversions are associated with no appreciable discontinuity of wind. (For theoretical reasons this means that they are horizontal.)

At present the aerological data are insufficient for any direct quantitative investigation, and similar remarks apply to the development of clouds from haze layers. In England most dry inversions are found above strato-cumulus clouds formed initially over the sea, and the most frequent level of the inversions is at about 4000 ft. in winter and 6000 ft. in summer. Over land in winter there is little tendency for the formation of strato-cumulus clouds, but only of fog or very low stratus.

C. K. M. DOUGLAS.

49 Oakley Street,
London, S.W.3, Jan. 22.

[1] NATURE, **129**, 97, Jan. 16, 1932.
[2] *Quar. J. Roy. Met. Soc.*, **55**, p. 133; 1929.

Melde's String vibrated by Rotating Pulley

IN view of the fact that in the violin the bow is often held inclined to the string, it was presumed that the bow produced both a longitudinal and a transverse force at the point of contact during bowing. The vibration of the violin string would, therefore, be the superposition of the vibrations due to these two separate forces.

To test this, a Melde's string was excited by passing it over a pulley and making the pulley rotate. This gave a constant longitudinal force acting upon the string. The vibration was excited quite easily. A length of 2 metres vibrated with the fundamental having an amplitude of about 3·5 cm. ($2a = 7$); the first harmonic had an amplitude of 2 cm. nearly, the second 1 cm. nearly. In the actual experiment the horizontal rotating axle of the viscosity apparatus (method of concentric cylinders) was used for the pulley. The string was passed round this axle and tied to two screws nearly 4 cm. apart. Sometimes the top string vibrated and sometimes the lower, as the tension in the two strings was adjusted. This showed that the effect was not spurious and was not due to any transverse motion of the axle. The tension away from the fixed end generally gave the lower frequencies, the tension towards the fixed end the higher ones.

The string was next passed over a smooth pulley rotating at right angles to the length of the string. The middle pulley of the step-down gear of the Callendar's apparatus for the determination of J was used for the purpose. The fixed end of the string was placed as close to the pulley as possible. The vibration could be seen to have a frequency absolutely distinct from that of the pulley, being much higher than it. The amplitudes worked up compared with the amplitudes for the longitudinal mode of excitation.

The production of continuous motion by vibration is well known. The reader may take the experiments here described as the converse of experiments discussed by Taber Jones [1] and by Morton and McKinstry.[2]

SATYENDRA RAY.

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[1] *Phys. Rev.*, **2**, p. 150; 1918; and **27**, p. 622; 1926.
[2] *Phys. Rev.*, **29**, p. 192; 1927.

Cytology of the Mycetozoa

IN reply to Miss Lister's recent communication,[1] I should like to raise the following points:

1. The statement concerning the spore-wall, p. 106 of my paper,[1] is meant to apply particularly to *Didymium nigripes* var. *xanthopus* and not generally to other members of the Mycetozoa. The complete statement is as follows: "The spore of *Didymium nigripes* is rounded to oval in shape and approximately 10 to 12 μ in diameter. The spore membrane is comparatively thin, consisting of a single dark-coloured layer, 2 μ in width, and not of two layers as stated in Lister's Monograph."

2. I do not wish to disregard the monospore cultures made by other investigators, but merely to point out that I have had difficulty myself. Indeed, I am of the opinion that there is a much greater possibility of obtaining satisfactory monospore cultures in *Didymium nigripes* var. *xanthopus* than there was in Reticularia (p. 126). On p. 99 I refer to Cayley's monospore cultures and express the hope that I shall be able to repeat my endeavour to isolate single spores, using her method.

3. On p. 129 I refer to the discovery of flagellate fusion in *Didymium difforme* by Cayley, but I do feel that such a conclusion should be supported by investigation of nuclear detail in stained preparations.

4. I have already apologised to Miss Cayley for having misunderstood her views concerning the connexion of sex segregation with meiosis, and am sorry that I was so much influenced by her diagram, which she admits is rather misleading.

I should like to thank Miss Lister very much for the great interest she has shown in my work, and I trust that the above will make quite clear the points she raises.

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Jan. 26.

[1] NATURE, **129**, 131, Jan. 23, 1932.
[2] *Trans. Roy. Soc. Edinburgh*, **56**, 93-142; 1931.

Research Items

Excavations at Fara.—A preliminary report by Dr. Erich Schmidt on a short season's work at Fara appears in the *Museum Journal* (Philadelphia), vol. 22, 3-4. Fara lies north-west of Ur. The surface of the mound was much disturbed by the Koldewey Expedition of 1902–3. Work was confined to a few test plots at points of medium height, three to eight metres above plain level. The original ground surface level was attained in one group of twin plots. Three strata or periods were distinguished. Fara III is a settlement of the time of the third dynasty of Ur (2400–2300 B.C.) which was known as Shuruppak. As the remains of Fara II begin immediately below the surface of the mound, the only evidence for the existence of this settlement in the plots investigated is that yielded by a well-built circular construction of brick which proved to be a granary of the second period filled in by debris, including a number of human skeletons, of the third period. One of two cuneiform tablets speaks of 'the year when Gimil-Sin became king'. The most striking finds were a number of pottery figurines or 'plaques', valuable especially for the style of dress and the insignia of royalty or deity. Fara II, 'the Early Sumerian', found immediately below the surface and extending down to a sterile stratum, saw the climax of the life of the mound, when it was large and wealthy. The finds included a large number of archaic inventory tablets. Lumps and fragments of copper were found at all depths. Below the sterile layer is Fara I, 'the Painted Pottery period', comparable to Jemdet Nasr culture, with suggestions of, but as yet no very definite clue to, the earlier al'Ubaid period. Fara I has as yet provided no written records. Fara, like Ur and Kish, thus supplies evidence of an inundation; but the occurrence of pottery and seals of Fara II in association with the Jemdet Nasr levels is interpreted to mean that while the Jemdet Nasr and 'early Sumerian' cultures were independent, they yet lived side by side during the infiltration of the Sumerian and until Jemdet Nasr died out.

Inheritance of Intelligence.—In a recent study of the relation between intelligence and inheritance, by Miss E. M. Lawrence (*British Jour. Psychol.*, Monograph Supplements, 16), the Stanford-Binet tests and, in certain cases, tests devised by the National Institute of Industrial Psychology, were applied to several groups of children of school age. One group is the inmates of a home for illegitimate children separated from their parents at an average age of six months, another group consists of the children in an institution which admits children who need a home for any cause, two groups were from poor law homes, and the fifth from a London elementary school. Various statistical comparisons are then made between the I.Q. of the children and the social class of the parents. One conclusion reached is that even if the child has never lived with its parents, it is likely to have a slightly higher intelligence if its parents came from the upper classes than if they came from labouring people, although there are numerous exceptions both ways. The association of intelligence with class is greater for children who remained longer in their own homes, but the intelligence of children removed from bad surroundings apparently does not improve in a good environment. All the figures show a big drop in intelligence level with age, which means that the tests for successive years are too steeply graded. Illegitimate children are not significantly more or less intelligent than others. Various other relationships are brought out in this paper, which concludes with a bibliography of the recent literature on this subject.

Physiology of Rheumatism.—Ll. J. Llewellyn and A. Bassett Jones suggest that 'rheumatism' is the result of the body's failure to adapt itself to its physical environment, or atmospheric changes in their widest sense (*Brit. Jour. Physical Medicine*, vol. 6, p. 181; 1931). It is well known that rheumatic subjects are abnormally sensitive to changes in the weather; moreover, rheumatism is much more prevalent in the temperate zone with its variable climate than in the frigid or torrid zones. It is probable that the sympathetic nervous system and the endocrine glands are involved in the response of the body to changes in its environment, and that some deficiency in the response of these systems is the ultimate cause of the body's failure of adaptation. Thus the response to changes in temperature largely depends on the proper functioning of the sympathetic nervous system, owing to its control of the sweat glands and the distribution of blood in the body; a high external temperature results in sweating and dilatation of the skin blood vessels, by which means the surface of the body is cooled. The skin must play an important part in this adaptation, since it is the receptor for many of the stimuli impinging upon the body, as well as being the chief site of heat loss. Now, the skin contains unusual amounts of the amino acids, tyrosine and cystine (presumably in protein combination); tyrosine is closely related to adrenaline and thyroxine, the active principles of the medulla of the suprarenal and of the thyroid glands respectively, both of which play important parts in heat production in the body; tyrosine and cystine are also constituents of insulin. The authors suggest, therefore, that ultra-violet rays, for example, can mobilise tyrosine from the skin (a process comparable to the conversion of ergosterol to vitamin D), and thus affect the supply of thyroxine and adrenaline to the tissues in general; and that rheumatism may be the result of an inadequate supply of tyrosine and cystine in the skin together with deficient exposure to sunlight.

Protective Coloration of Birds' Eggs.—In the recent number of the *Journal of the Bombay Natural History Society* (October, p. 250), Mr. E. C. Stuart Baker describes a case discovered by Mr. J. Stuart of localised protective coloration in the eggs of a ground-nesting bird, the yellow-wattled lapwing (*Lobipluvia malabarica*), which, on a belt of brick-red laterite soil stretching along the Malabar coast into Travancore, lays remarkably assimilated red eggs, but earthy coloured ones on the black soil areas around. The conclusion is drawn that, as the birds increased on the black soil, some were forced to colonise the red belt, and here only such eggs as exhibited a reddish tinge could escape vermin, so that in the course of generations the red protective type was evolved. In view of the well-known proneness of eggs to mutation, a simpler explanation would seem to be that the birds originally bred indiscriminately over the whole area, that some red egg-laying mutants were always present, and that these only could maintain themselves on the red soil belt.

Yagé, a South American Drug Plant.—Extensive collections of Indian drug plants made by Mr. Guillermo Klug, of Iquitos, Peru, in the Putumayo region of south-eastern Columbia, include three species of *Banisteriopsis* (family Malpighiaceæ). These plants are known by the Indians under the general name of 'yagé', and they are boiled until

a syrup is produced. To this is added leaves and young shoots of a particular species of the genus, and to this is attributed the ' bluish aureole ' seen by the Indians in the state of anæsthesia into which they fall after drinking the liquor. The liquor appears to excite the cerebral centres of vision, and it is stated that, as a result, their sensibility is so developed that after drinking yagé a person is capable of " seeing objects in the midst of the most complete obscurity ". Mr. Klug was also informed that this drink was a very effective cure for malaria. Specimens from Mr. Klug's collections have now reached the United States National Museum, and Mr. C. V. Morton has described a new species (*J. Wash. Acad. Sci.*, vol. 21, No. 20, 1931), with notes on the action of the drug supplied by Mr. Klug.

Composite Nature of Potato Virus Diseases.—Dr. Kenneth Smith, in his recent paper " On the Composite Nature of Certain Potato Virus Diseases of the Mosaic Group as revealed by the Use of Plant Indicators and Selective Methods of Transmission " (*Proc. Roy. Soc.*, B, **109**, pp. 251-267; see also NATURE, **127**, 702, May 9, 1931), has brought good evidence to show that the mosaic, crinkle, and streak diseases of potatoes are each caused by more than one virus. The aphid *Myzus persicæ*, Sulz., will not carry any of the diseases mentioned as a whole, but only one or more of the component viruses. Plant indicators, such as tobacco, are also used, for when a composite mosaic is inoculated on them they show different symptoms if more than one virus is concerned. Plants of *Datura Stramonium* and *Petunia* are susceptible to one of the viruses, but not to the others. It is also found that the component viruses have different incubation periods and different rates of transmission within the host plant. This also can be used to separate them. Two viruses, named provisionally x and y, have been isolated from a symptomless ' streak '-carrying potato (Up-to-Date), and y seems to be a widespread component of potato virus diseases. The work here reported should go far towards standardising our knowledge of the diseases which cause the so-called potato ' degeneration '.

Reactions of Horizons in Tropical Soils.—This subject is discussed in relation to the soils of Nyasaland by A. J. W. Hornby in a letter in NATURE for Jan. 9, p. 58. It is also one of the many interesting points dealt with by D. S. Gracie in a pamphlet on " A Preliminary Survey of Some of the Soils in Kenya " (*Bull.* 1, 1930, Dept. Agri., Kenya). These surveys were carried out on a profile basis to a depth of five feet; for it was realised—and the importance of the point clearly demonstrated in the course of the work—that although the surface layers are the more intimately connected with the crop, yet subsoil conditions may necessitate considerable modification of conclusions derived from a study of the surface layer alone. Instances are cited where the acidity increased continuously with depth, but no indication of these undesirable conditions was shown in the surface soil, the agricultural value of which, however, was seriously affected. Soil colour is also intimately associated with soil fertility, for removal and redepositions of iron, which are closely correlated with the degree of acidity and the amount of humus that is lost, are accompanied by changes in the colour of the soil. Another factor of fundamental importance is the nature and amount of organic matter present. This is found to be, under natural conditions, a function of the exchangeable calcium, the degree of acidity, and the climate, for acidity or lack of available calcium arises from lack of suitable organic material. That climatic conditions also play a part is well brought out by a comparison of the humus content of soils (similar as regards exchangeable calcium and pH value) from different altitudes. Throughout the survey the practical aspect, that is, the value of the of soil to the agriculturist, has been kept in the foreground, and a section of the bulletin is devoted to a discussion on the improvement and maintenance of the fertility of soils of different derivations.

Algal Origin of Petroleum.—An important paper to those interested in the biochemical aspects of petroleum genesis was communicated to the Institution of Petroleum Technologists on Jan. 12 by Mr. J. E. Hackford. As he rightly points out, the origin of oil from decomposition of marine vegetation is a generally accepted thesis in many cases, but the precise mechanism of the chemical actions involved has lacked detailed investigation. In practically all accounts of the organic origin of petroleum, the geochemical processes contributing to its formation are stated with almost convincing logicality, but the mist becomes nearly impenetrable when information is sought as to the manner in which organic debris gradually changes into the oily globule and the precise chemical circumstances involved. The author claims to have established the formation of oil from algæ by processes similar to those obtaining in Nature; the presence of decomposition products of algæ in both naturally occurring oils as obtained from wells and also from seepage oils and bituminous deposits; the reconversion of oils into materials closely resembling, sometimes identical with, the constituents and decomposition products of algæ; the formation of oils from sugars; and the reconversion of oils into bodies resembling bitumens which upon hydrolysis yield sugars. The work as a whole supports the algal theory of the origin of some classes of petroleum, and goes further than this: that oil and bitumen are in the main produced from the sugars resultant upon the hydrolysis of algæ. From this, the author concludes that the vegetal theory of origin should be renamed " The Carbohydrate Theory of the Origin of Oil ". This is one of the most interesting, if not provocative, papers presented to oil technologists for some time past, and the conception of the fucosite-petroleum cycle, as it is called, constitutes a welcome advance in this difficult domain of biochemistry.

Nature of the Carbon Dioxide Molecule.—It has been suggested from the way in which the specific heat of carbon dioxide alters with temperature that it exists in two forms, one straight and the other slightly bent, but conflicting results for the dielectric constant have made it impossible to decide from this if the bent form, which should have a permanent dipole moment, does actually exist. T. L. Ibbs and A. C. R. Wakeman have recently described a series of experiments on the thermal diffusion of carbon dioxide in gas mixtures, and on its viscosity, which seem to decide the point at issue (*Proc. Roy. Soc.*, Jan.). With both phenomena it has been found that sharp changes occur in the curves connecting the numerical measure of the effect with the temperature, at about 140° C. In the case of diffusion, the transition temperature is 146° for a hydrogen mixture and 144° for a nitrogen mixture. This change is described by saying that the carbon dioxide molecule is ' hard ' above 145° and ' soft ' below this temperature. In the case of the viscosity, the change occurred at 140°, in excellent agreement with the results of other experimenters. From a discussion of these and other data it is suggested that the ' soft ' and ' hard ' modifications have, respectively, the straight and bent structural formulæ.

Hydrides of Boron.—The preparation of the hydrides of boron by the usual method of the interaction

between an acid in aqueous solution and an alloy of boron gives very poor yields and is long and tedious. Schlesinger and Burg have described (*J. Amer. Chem. Soc.*, Dec. 1931) a method for the preparation of diborane, B_2H_6, which consists in the reduction of gaseous boron trichloride by hydrogen in an electric arc discharge at low pressure. Boron, various non-volatile hydrides and large yields of an unstable spontaneously inflammable substance, considered from its reactions to be B_2H_5Cl, are also formed. The last-named compound, however, on warming decomposes and gives a further quantity of diborane: $6B_2H_5Cl = 5B_2H_6 + 2BCl_3$. When diborane containing a small quantity of hydrogen chloride is heated at 120°-130° a considerable proportion is converted into the more stable pentaboron hydride B_5H_9.

Aromatic Nitroso-Compounds in Solution.—The apparent molecular weights of nitrosobenzene and a number of its derivatives were determined in dilute solutions, mostly in benzene, by Bamberger and co-workers, and the results seemed to indicate that the state was unimolecular. Hammick has shown that these results are ambiguous, and has described new experiments with co-workers on nitrosobenzene and several substituted products (*J. Chem. Soc.*, Dec. 1931). The results show that nitrosobenzene itself and its meta- and para-derivatives are associated in dilute solution. In the case of mono- and di-ortho-substituents a steric effect was detected. The degree of association of nitrosobenzene itself is quite small, about 2·4 per cent, but in some of the derivatives large associations were found, such as 38·2 per cent for o-nitronitrosobenzene and 77·3 per cent for nitroso-mesitylene. In the di-ortho-substituted derivatives there is enormously enhanced stability of the bimolecular form. The first step in association in the case of nitrosobenzene is thought to be dipole association, although it is considered unlikely that the bimolecular forms of nitroso-compounds are simply dipole aggregates, and the dipole aggregate is thought to pass into an oxyazoxy-structure.

A Compound of Nitrobenzene and Sulphuric Acid.—A compound, $C_6H_5NO_2$, H_2SO_4, separates on cooling an equimolecular mixture of the two components, the melting point, 11·6°, being higher than that of either component. Masson has published (*J. Chem. Soc.*, Dec. 1931) a complete freezing-point diagram for the two substances, which shows a well-defined maximum corresponding with the equimolecular compound and two eutectics, so that probably this is the only compound formed. The compound forms colourless needles at low temperatures, but at room temperature is an oily liquid which is surprisingly sluggish towards water and does not liberate much heat when decomposed by it. In sulphuric acid it forms solutions which conduct better than the acid alone, so that the compound is regarded as an electrolyte $(C_6H_5.NO_2.H)^+(HSO_4)^-$, the hydrogen ion or proton being co-ordinated with one of the oxygen atoms of the nitro-group. The attachment of the positive hydrogen ion to the nitro-group should promote meta-substitution in the same way as happens with an arylammonium ion. The stability of the compound suggests, indeed, that in the dinitration of nitrobenzene it may well be the positive nitrobenzene-hydrogen ion, rather than the neutral nitrobenzene molecule, which is the main organic reagent and thus the source of the preponderating meta-derivative.

Astronomical Topics

Reinmuth's New Object.—Dr. Kahrstedt has published elements of this object in *Rech. Inst. Circ.* 534, as follows:

T	1933 Oct. 28·2854 U.T.	
ω	96° 34′ 0″	1932·0
Ω	45 46 21	
i	31 14 21	
e	0·1624184	
log q	0·6578513	
Period	12·65425 years.	

The orbit is still very uncertain, the arc being short. The object appears to be of the same type as comet Schwassmann-Wachmann (1), but with a somewhat smaller orbit that comes inside that of Jupiter at perihelion. The orbit makes a near approach to that of Jupiter at the descending node. The above cicular gives an ephemeris for February and March, but as the comet is fainter than mag. 15, it is not given here.

Rech. Inst. Circ. No. 540, dated Jan. 30, states that Prof. M. Wolf has changed his opinion about the object, and no longer considers that it is nebulous: it may, therefore, be a minor planet, not a comet; but even in this case it deserves attention, as its orbit appears to be of an unusual type.

The Light Variation of Cepheids.—*Meddelande* of Lund Observatory, Series I., No. 128, contains a study by Dr. K. Lundmark of the correlations between period and magnitude and between period and amplitude of light-change in the Cepheid variables. He includes in his study the stars in the Magellanic Clouds, the nearest two spiral nebulæ, the globular clusters, also galactic Cepheids. Graphs are given for the Cepheids in all these different regions; they agree in showing a close correlation between magnitude and logarithm of period, when the maximum magnitude is used; there is greater departure from a linear graph when the minimum magnitudes are used. There are also clearly recognisable correlations between amplitude and magnitude, but the graphs are more curved. It is noted that Dr. Hertzsprung found little trace of this last correlation in the stars near Eta Carinæ; but probably the stars that he was discussing were at very different distances.

Dr. Lundmark uses his adopted curves to obtain new estimates of the distances in light-years of the various objects; of course, they do not differ much from those already published. He finds for the Greater Cloud 95,000 light-years, for the Lesser one 112,000 light-years, for N.G.C. 6822 690,000 light-years, for the Andromeda nebula 840,000 light-years, for Messier 33 860,000 light-years; the distance between the last two objects would be 224,000 light-years.

Rocznik Astronomiczny, Cracow Observatory.—No. 10 of this annual publication, edited by T. Banachiewicz, contains the ephemerides of variable stars which the above observatory undertook to compute, with the aid of grants from the I.A.U. and the Polish Minister of Education.

It includes 44 eclipsing variables with period less than 18^h, 219 with period between 18^h and 10^d, and 26 with periods exceeding 10^d. Elements, but not ephemerides, are given for 32 other stars. The ephemerides are heliocentric. For reasons of economy, stars south of Decl. −23° are omitted this year, also the index of ephemeris-stars.

The volume also contains certain coefficients for calculating precessions and the times of occultations of stars by the moon for five observatories in Poland. The explanations, and the headings of tables, are in flexible Latin, which is easy to read.

Research on Springs *

THERE are few people at the present time who are not interested in springs of some kind. That large section of the general public which uses the automobile, either for business or pleasure, generally finds at some time or other that the breakage of a circular spring round a valve stem or of a flat spring on the suspension system may be responsible for an amount of inconvenience out of all proportion to the seriousness of the accident.

Even government departments are liable to such troubles, and both during the War and for some years after, the Chief Inspector of Mechanical Transport of the War Office directed attention to the unsatisfactory position in relation to the design and performance of laminated springs for mechanically propelled vehicles. Failures of valve springs in aircraft engines were reported by the Air Ministry, and both the Admiralty and the War Office were experiencing difficulties with spiral springs. In the motor-car trade there was much trouble associated with the use of valve springs on high-speed car engines and generally where the working conditions were severe.

Due to the representations made to the Department of Scientific and Industrial Research, a Springs Research Committee was appointed in 1922, with the main object of carrying out such inquiries and researches as would result in the improvement of the materials and design of laminated and spiral springs. Since that time much work has been done by the different sections of the Committee, and the results of their investigations have been published from time to time. In the Report just issued, a general survey is made of the whole of the Committee's work and the definite conclusions to be drawn from it are summarised.

It will be found that the field covered by the Committee is a very wide one. Naturally the researches into the properties of spring material bulk largely in the Report, but much work has also been done in perfecting methods of testing complete springs and of finding the oscillating and loading conditions to which springs are subject under road service.

The most striking conclusion reached is that, with springs as ordinarily manufactured and used, the high stress-resisting properties of which the spring material is capable are not realised. Spring material of many types has been tested under a wide variety of conditions, and has shown itself to be capable of resisting wide ranges of repeated stress for long periods. When, however, this material is converted into springs, breakage occurs at stress ranges of from about one-quarter to one-half of what should have been resisted.

The explanation given for this surprising discrepancy is that a surface weakness is developed during the heat treatment and other manufacturing processes. Experiment has shown that this deleterious surface layer is very thin, and that the full resistance value of the material can be regained by machining about one-sixteenth of an inch from the surface of the spring. With spring steel wire the same conclusions hold; in all grades of wire tested the 'surface effect' was evident even when the wire had been manufactured under special conditions. It is, therefore, not surprising that the Committee recommends that manufacturing methods should be developed for the production of spring steel in plates or wire which shall utilise the full intrinsic fatigue strength of the material.

The Report should be of value both to the user and manufacturer of springs. It is an excellent illustration of the value of co-operation between science and industry, since, largely as a result of a systematic and detailed programme of research, both an explanation and a remedy have been found for a trouble responsible in the past for many serious consequences.

* Department of Scientific and Industrial Research. Report of the Springs Research Committee. Pp. iv + 75. (London: H.M. Stationery Office, 1931.) 1*s.* 3*d.* net.

The Dating of Pueblo Ruins in Arizona

EXCAVATIONS undertaken on four sites in Arizona, Kin Tiel and Kokopnyama, north of the Little Colorado River, and Pinedale and Showlow in the forested area to the south, have furnished evidence which will now make it possible to date the phases of Pueblo culture with accuracy over a period of 1200 years.

The researches in dendro-chronology, as applied to Pueblo archæology, which were undertaken by Dr. A. E. Douglass at the invitation of the National Geographic Society while the famous ruins of Pueblo Bonito were under excavation by one of its expeditions, have established two sequences of ring records in the course of three 'Beam Expeditions' to the Pueblo area.

For one of these the coincidence and overlap of the annual rings in pine log beams from the still inhabited Hopi village of Oraibi were worked out, in accordance with the system elaborated by Dr. Douglass, from the normal and subnormal growth of rings according to rainfall, to show a complete historical sequence back to about A.D. 1260. By the same method a prehistoric sequence was established, extending back over 580 years on the evidence of beams from the Citadel ruins at Mesa Grande and Pueblo Bonito, thus going back into the third of the five periods of Pueblo culture, of which the fifth and last extends from the Spanish conquest in the sixteenth century to the present day.

The excavations at the four sites mentioned were undertaken in the hope of finding a link which would connect the prehistoric and historic sequences and substitute an absolute dating for the relative dating of the earlier period. It was thought that such a link would be provided by the study of a certain transient type of Pueblo pottery, for which no date was available, but which, it was thought, would furnish a clue to ruins immediately antedating the still inhabited Oraibi village. A reconnaissance of twenty prehistoric villages was made before the four sites in question were selected.

The accounts of the chronological and archæological results obtained by Dr. Emil W. Haury and Mr. Lyndon Hargrave at Showlow and Pinedale, and by the latter at Kin Tiel and Kokopnyama (*Smithsonian Miscellaneous Collections*, vol. 82, No. 11), provide some indication of the far-reaching effect of the application of an absolute and accurate chronology to the investigation of Pueblo antiquities. So far as the main objective of the expedition is concerned, timbers were recovered which linked together the two date sequences and carried back the tree ring calendar to A.D. 700. A beam, to which the field notation *H.H.* 39 has been given, was found at Showlow which proved the key beam converting the relative dating into an absolute chronology. The outer rings could be read at about A.D. 1380, while its central ring dated at A.D. 1237. The innermost rings coincided with the

last rings of the prehistoric chronology and the outer rings were readily identifiable with the thirteenth and fourteenth century records of the historic sequence. Further excavations yielded more logs which confirmed the record of the key beam.

As the last rings of any given beam give the cutting date, when it shows the true outside, it is obvious that it also gives an approximate date for the erection of the building in which it was used, provided there is no evidence of re-use. Thus at Showlow it was possible to reconstruct the history of the building. The beams showed a period of reconstruction at about A.D. 1380, with periods of activity at 1204 and 1272, while re-used beams gave dates ranging from 1175 to 1356.

The manner in which the archæological and chronological conclusions confirm and supplement one another is well illustrated in the reports of the investigations. There are, for example, three horizons which are dated respectively at A.D. 1204 (Showlow), 1290 (Pinedale), and 1375 (Showlow), and the sequence of the styles of pottery associated with each is confirmed. The chronological evidence indicates the length of time by which culture features survive in a marginal area while dying out in the centre of origin. Thus Chaco traits are shown to exist in the pottery a hundred years after the Chaco Canyon culture ceased to exist. Further, it confirms the views of those who argued on the basis of stratigraphy that lead glaze existed in the Pueblo culture before the advent of the Spaniards, as against those who maintained that it was improbable that it could have been used by the Pueblo potters in the prehistoric period. Dendrochronology shows that it was employed fully two hundred years before the arrival of the Conquistadores.

The Climate of Japan

IN the *Bulletin of the Central Meteorological Observatory of Japan*, vol. 4, No. 2, Prof. T. Okada gives a very thorough discussion of the climate of Japan. It is divided into three sections, entitled, "Climatography", "Climatology", and "Climatic Tables".

The first section opens with an interesting discussion on general lines of the main features of the climates of the different climatic zones into which the country can conveniently be divided, and outlines the main factors that are responsible for the primary characteristics of these. Each region is then discussed in greater detail. In the second section the method of arrangement is not geographical, but according to each climatic element: for example, air temperature, wind direction and speed, rainfall, and so on. The last section is entirely occupied with tables showing the seasonal variation of different elements; it is followed by a general index, and then by thirty-five plates setting out graphically the seasonal or geographical variations of the elements discussed earlier in the work. The magnitude of the work and the wealth of detail that it gives about a region where the organisation of climatological work on modern lines has naturally been undertaken at a later date than in Europe make it indispensable as a work of reference for professional meteorologists.

The climate of Japan, owing to the peculiar situation of that country, at no great distance from those parts of Asia which present the greatest contrasts between summer and winter to be found anywhere in the world, is a particularly interesting one; it provides an example of what Okada describes as "an extreme climate characteristic of a continent" in spite of its insular position. The winter is dominated by the prevalence of cold air flow from China. This flow does not take place across a sufficient width of sea for the latter to have very much tempering effect, but although the wind is often very strong, there is time enough for the air to acquire a considerable amount of water vapour, and this tends to condense when the air ascends to pass across the land. The result is that "gloomy weather with snowfall prevails on the side facing the Japan Sea, and rain showers occur almost every day in the Ryûkyû or Loochoo Islands and northern Formosa. Therefore, on this side of Japan proper, snow lies deep on the ground and a thick veil of clouds overcasts the sky. Fine days are phenomenal." On the Pacific side, however, fine weather generally prevails at this season. In the islands to the south of Japan proper the influence of the Asiatic winter monsoon is overshadowed by that of the warm ocean, and luxuriant tropical vegetation can flourish.

During the summer, when the Asiatic area of high pressure disappears, to be replaced by relatively low pressure and a complete change of wind circulation, an inflow of air takes place, which crosses Japan mainly from between south and east; it is feeble and less constant than the winter monsoon, especially during the principal rainy season called the Bai-u, which comes in late June and early July. These winds do not give rise to the contrasts of climate on the windward and leeward sides of the islands found in winter, nor is there so much variation of temperature with latitude; the result is a generally hot and humid climate, appropriate to maritime conditions in those latitudes.

In conclusion, some reference must be made to a very noticeable feature of all except the southern sea-dominated parts, and that is the shortness of the spring and autumn seasons. In the north, snow may still be lying early in May, although June generally brings the heats of summer; autumn does not extend much beyond the month of October, for the cold winter winds are usually well developed by November. E. V. N.

Weather Forecasting

IN his Friday evening discourse at the Royal Institution on Feb. 5, Dr. G. C. Simpson discussed weather forecasting. In 1859, Admiral FitzRoy, who was then the head of the department of the Board of Trade which had recently been established to study marine meteorology, commenced to collect weather reports by telegraph from a number of ports in the British Isles, and so a new science was created and a new term added to the English language. FitzRoy's innovation was not approved by scientific men, and on his death in 1865 forecasting ceased.

The public had, however, found the forecasts useful, and considerable pressure was brought to bear on the Meteorological Office to recommence the forecast service. A new attitude was possible owing to the introduction of the synoptic chart showing the distribution of pressure by isobars, the lines with which we are now so familiar on the published weather maps. It had been found that isobars could be classified in a number of types of which the most familiar are the cyclone and the anticyclone. This remained the basis of forecasting until the War, and it is still largely

employed. The method is entirely empirical and needs no knowledge of the physics of the atmosphere.

We now recognise that weather is produced by the bringing together of great masses of air from polar and tropical regions by the general circulation of the atmosphere. Such masses of cold and warm air do not readily mix, but overrun or undercut one another along 'fronts' which can be traced for hundreds of miles on the synoptic charts. The recognition of fronts has given the forecaster a powerful new tool for the study of what is actually taking place in the atmosphere, and has greatly improved the short period forecasts, especially those for aviation.

A synoptic chart which extends only over a single country is not of much value for forecasting; it is necessary to know the weather conditions over a much larger area. To meet this need there is very close international co-operation between the official weather services of the different countries. At certain specified times each day observations are taken at forty-five stations in the British Isles and on a number of ships on the Atlantic and telegraphed to London.

The same procedure is taking place in every other country. The meteorological office in Paris takes in these national messages from countries in western Europe, and the German meteorological service does the same for central and northern Europe, while Moscow deals with the whole of the great area of the U.S.S.R. Paris, Hamburg, and Moscow then reissue the messages they have collected from wireless stations sufficiently powerful to be heard all over Europe, according to a programme carefully drawn up by an International Committee. In this way information from more than five hundred stations in an area extending from Spitsbergen and Greenland in the north to Morocco, Algeria, and Egypt in the south, and from the middle of the Atlantic in the west to Russia and Palestine in the east is available in every meteorological office in Europe within two hours of the time at which the observations were taken. The whole programme of collecting and disseminating the observations is repeated three times a day by most countries, at 7 A.M., 1 P.M., and 6 P.M. G.M.T., and a certain number of countries add another set of observations at 1 A.M.

Unfortunately, no method has been found for expressing the success of weather forecasts by giving the percentages of failures and successes, but those who have to examine every day's weather in the light of yesterday's forecast know that there has been an appreciable increase in the accuracy of the forecasts and also in the amount of detailed information it is possible to include in them.

University and Educational Intelligence

CAMBRIDGE.—Prof. P. Debye, of the Physical Institute at Leipzig, has been appointed Scott lecturer for the year 1932.

Dr. E. B. Worthington (Balfour student) will lecture on Feb. 17, at 5 P.M., in the zoological lecture room, on the "Great Lakes of Africa".

A COURSE of eight bi-weekly lectures on the "Optical Principles of Television" will be given by Dr. W. D. Wright at the Imperial College of Science and Technology, South Kensington, London, S.W.7, on Tuesdays and Thursdays at 4 P.M., commencing on Feb. 23. Further information can be obtained from the Registrar of the College.

THE Council of the University of Melbourne has passed a resolution expressing to Mr. F. Chapman, Commonwealth palæontologist, on his retirement from the position of part-time lecturer in palæontology after twelve years' service, its thanks for the help which by his wide knowledge and great experience of palæontology he has rendered to the Geological Department of the University.

EDUCATION during the past ten years in Porto Rico is reviewed in a leaflet recently issued by the U.S. Office of Education, Washington. The review is of more than local interest by reason of the description it contains of a seemingly successful experiment in rural education of a vocational type. Thirteen consolidated rural schools have been established for pupils aged eleven years and upwards, for whom the education hitherto provided in the fourth and higher grades in Porto Rican schools offers but little hope of increasing their earning capacity. In these new 'second-unit' schools only half of the day is devoted to academic subjects, the other half being given up to vocational work, namely: for the boys, agriculture, animal husbandry, woodwork, house-wiring, tin-smithing, auto-mechanics, shoe-repairing, hair-cutting, clay work, and toy-making; for the girls, cooking, sewing, and hand and machine embroidery and lace-making; and for both, hand-weaving. Agriculture is a required subject for all boys and home economics for all girls. The boys raise a large variety of vegetables, which are sold or consumed in the school lunch-room, one-third of the cash value of produce sold being given to the boys who raised it. The children are encouraged to cultivate home gardens, of which there are more than 15,000. As a result of this system the quantity and quality of fresh vegetables available to the rural communities have improved and family incomes increased. The boys are taught also to plant the principal crops and to raise pigs, chickens, rabbits, pigeons, and goats. The breeds are being rapidly improved. The lessons in cooking aim at a diet based largely on Porto Rican produce, and the results are tested in the school lunch-room. It is noteworthy that this experiment, which is one of the fruits of an educational revival brought about by a survey conducted in 1925 under the direction of Dr. Paul Monroe of Teachers' College, Columbia University, was undertaken during a period of severe retrenchment in educational expenditure.

Calendar of Geographical Exploration

Feb. 16, 1623.—Arnhem Land

Jan. Carstenzsoon on an expedition in which two ships, the *Arnhem* and the *Pera*, took part, sighted the snowy mountain chain of central New Guinea. Mt. Carstenz, more than 15,000 feet in height, takes its name from him. The two ships became separated: Carstenzsoon in the *Pera* discovered and named several rivers in the York peninsula. Although the lands discovered by the *Arnhem* are not exactly known, the vessel explored the region between 9° and 13° S. in that part of the Northern Territory, Australia, now known as Arnhem Land.

Feb. 16, 1816.—The Congo Cataracts

Capt. Tuckey, with a party which included a botanist, a geologist, a naturalist, and a comparative anatomist, left England commissioned by the Government to ascend the Congo. Another party was sent to the Niger, and it was hoped that the two might eventually meet, Mungo Park's explorations having failed to clear up the question of the separate identity of the Niger and the Congo. Tuckey's party reached the first cataract of the Congo and thence attempted

exploration by land. Disease, however, overtook the party and they returned to the ship, where Tuckey and others died. The companion expedition, which had landed on Dec. 14 at the mouth of the Rio Nunez, midway between the Gambia and Sierra Leone, met with equal disaster, disease and discord with the natives resulting in the death of most of the party.

Feb. 18, 1865.—Colonel Pelly in the Nejd

Colonel Lewis Pelly, British resident at Bushire, set out from Koweit with a small caravan, and after five waterless days in the desert reached the wells of Orma at the foot of Jabal Tueik. On March 5 he reached Riyadh. On the return journey the guide led Pelly's party by a route considerably to the north of Hofuf; all the main lines of relief were found to run north and south, and seven distinct ridges had to be crossed in the descent from the Tueik plateau to the coast. He covered some previously unexplored regions, but was unable to take as many measurements and observations as he had hoped owing to the need for haste in view of political difficulties. Pelly was the first representative of a European government to venture into the centre of the Arabian peninsula openly avowing the nature of his mission.

Feb. 20, 1844.—Between the Mississippi and the Pacific

J. C. Frémont, one of the greatest of American explorers, reached the summit of the snow-covered Sierra Nevada mountains. He had started out in 1842 to explore the route beyond the Mississippi as far as South Pass in Wyoming. He ascended the second highest peak of the Wind River mountains which now bears his name and in the following year reached the Oregon settlements. Thence he turned south and east via the Klamath lakes to north-western Nevada and the Truckee and Carson rivers, covering much previously unexplored country. After crossing the Sierra Nevada he spent the rest of the winter on the Sacramento River, and returned round the southern end of the range to the Great Salt Lake, following the old Spanish trail from Santa Fé to California. Frémont had accompanied J. N. Nicollet, the French explorer, in his survey (1835–40) of the country between the upper waters of the Missouri and Mississippi rivers. In 1841, Frémont headed an expedition to the Des Moines River and thus completed Nicollet's map. His explorations opened up a great part of the country between the Mississippi valley and the Pacific Ocean. Frémont had a varied career, afterwards becoming soldier, politician, and multi-millionaire.

Feb. 20, 1848.—Northern Arabia

G. A. Wallin, a distinguished Arabic scholar, who afterwards became a professor in the University of Helsingfors, left Muweila on the second of his famous journeys in northern Arabia, travelling disguised as a learned Arab sheik. Striking inland across the unexplored granite mountains, he reached Tebuk, an ancient village on the Syrian pilgrim route. Thence he proceeded to Teima, crossed a tongue of the Nafud, and after a month's stay at Hail accompanied a party of tribesmen to Meshed Ali and returned via Bagdad. On a previous journey Wallin had started from Cairo and travelled via Maan over the Hamad to Jauf. Thence he had crossed the Nafud, seen the isolated grey granite chains of Jabal Aja and Jabal Selma, and penetrated to Hail. Of Medina and Mecca which he also visited he left no detailed account. Although he took no instruments, his full and minutely accurate reports gave a clear picture of the regions through which he passed, many of them never before visited by a European.

Societies and Academies

LONDON

Royal Society, Feb. 4.—**J. R. Baker** and **R. M. Ranson**: Factors affecting the breeding of the field mouse (*Microtus hirtus*)—(1) Light. The shortening the daily period of exposure to light from fifteen hours to nine hours almost stops reproduction in the field mouse, *Microtus hirtus*. The female is chiefly affected.—**T. H. Bissonnette**: Modification of mammalian sexual cycles; reactions of ferrets of both sexes to electric light added after dark in November and December. Male and female ferrets were subjected to doses of electric light during the night between October and January. Full œstrus was induced in the females in 38-64 days and successful coitus in 59-70 days. In the males interstitial cells were stimulated and copulation took place in 59 days, but no mature sperms were found even after 71 days. Birds differ from mammals in that the males are more responsive to doses of light than females. It is suspected that, with both birds and mammals, light may act through modifying anterior lobe activity, or susceptibility to it.—**R. N. Salaman**: The analysis and synthesis of some diseases of the mosaic type. The problem of carriers and auto-infection in the potato. As a result of both analytical and synthetic methods it has been possible to ascribe compositions in terms of X, Y, and Z to certain definite clinical virus diseases. The reaction of a virus complex is not the mere summation of that of its two constituents, but rather a linked group the strength of which varies according to the complex and the internal environment of the plant. At times a complex may break up either in an infected or a carrier plant, and one or other element becomes recognised as such. If this takes place in a carrier plant it is known as auto-infection.—**C. C. John**: The origin of erythrocytes in herring (*Clupea harengus*). During the first five months of development, the herring is devoid of red blood. The demersal egg hatches into a tiny larva in which the heart is at first a simple two-walled tube divided into two parts by a narrow constriction in the middle. The vascular fluid is colourless and does not contain any corpuscles. From deep water the larva migrates into mid water, and later to the coast. During this period the endocardium develops into a syncitial sponge-work in which numerous large nuclei develop; these ultimately migrate to the surface of the sponge-work and bud off into the vascular fluid as mother-cells of the red-blood corpuscles. At the 35 mm. stage the larva is at first rather opaque and the blood is colourless. When metamorphosis starts, a silvery sheen appears on the dorsal surface, and the body becomes opaque and the blood commences to turn red. A similar condition occurs during the development of the eel; in teleosteans in general the blood originates from the intermediate cell mass during the early embryonic stage, but in herring the hæmocytopoietic function is confined to the endocardium until the spleen develops.

Physical Society, Dec. 4.—**C. F. B. Kemp**: Some properties of the sound emitted by airscrews. A condenser-microphone amplifier system has been employed to determine the intensities and directional properties of the first six harmonics in the sound of rotation of an airscrew operating at zero rate of advance and actuated by a silenced engine. The sound-energy associated with the frequencies considered is 18 watts, the fundamental (first harmonic) being responsible for 50 per cent of this, while the first three harmonics together contribute 90 per cent.

Maximum intensity occurs at 15°-30° behind the plane of rotation, and in this region the sound-output is particularly steady. Large intensity-fluctuations occur along the axis of the slip-stream. The intensity follows the inverse square law of distance at points farther than 200 ft. from the airscrew centre, a 2·4-power law holding approximately for nearer points.—J. H. Awbery and Ezer Griffiths: The basic law of the wet-and-dry-bulb hygrometer at temperatures from 40° to 100° C. The relative humidity was measured both by absorbing and weighing the moisture in a known volume of air and by the dew-point method. The results are finally expressed by means of a skeleton table for the wet-and-dry-bulb hygrometer in the temperature range referred to.—J. H. Awbery: The water-content of saturated air at temperatures up to 100° C. The water-content of air which is just saturated has been measured at temperatures from 29° to 94° C. by absorbing the moisture and weighing it. To obtain saturation, air was bubbled through water in a thermostatically controlled bath. In some experiments the air was initially below saturation, whilst in others it was not and contained more moisture than would be necessary for saturation at the bath temperature.—Ezer Griffiths and J. H. Awbery: (1) The specific volumes of some gaseous refrigerants, (2) the latent heat of some refrigerants. The method used consists in permitting the liquid to evaporate repeatedly into an exhausted vessel so that automatically the vapour is under saturation pressure. The volume of the vessel is known, and the weight necessary to fill it is found from the decrease in weight of the liquid. The substances studied were sulphur dioxide, dichloroethylene, ether, pentane, and trichloroethylene. The latent heats of evaporation of ethyl chloride, methyl chloride, sulphur dioxide, pentane, and dichloroethylene have been measured over the temperature ranges lying between −18° C. and +25° C. The method used is an electrical one, in which a known amount of energy is supplied at constant temperature and the mass evaporated is obtained by weighing.

EDINBURGH

Royal Society, Jan. 11—Sir E. A. Sharpey-Schafer and W. A. Bain: The employment of intra-cardiac injections of adrenaline in asphyxia. In asphyxia caused by occlusion of the trachea, intra-cardiac injection of adrenaline has a marked effect in promoting recovery of the circulation. Even if the heart has ceased to beat for a short time, it will contract strongly and rapidly as the result of such injection, which should be made through the chest-wall, directly into the heart muscle. The adrenaline not only affects the heart but also the arteries, causing them to contract and thus keeping the blood pressure raised. Breathing recommences as soon as the circulation is restored, and although at first slow and deep, the respiratory movements gradually resume their normal character. The effects of the adrenaline injection are assisted by artificial respiration produced by intermittent pressure on the abdomen and lower part of the thorax.—B. P. Wiesner and Miss N. M. Sheard: Studies on maternal behaviour and its endocrine basis. Maternal behaviour in the albino rat can be prolonged by regularly replacing grown-up litters by small ones. The stimulus value of young with respect to maternal responses is inversely proportional to the age of the young. Determination of the age of the oldest young which is still retrieved by a female represents a method for evaluating the intensity of the retrieving drive. Oophorectomy before or after parturition does not interfere with the development or persistence of maternal behaviour. Injection of ovarian hormones in nulliparous females so far has not produced maternal behaviour. Injection of ammonia extracts from the anterior lobe of the pituitary produces maternal behaviour of varying intensity in both oophorectomised and intact nulliparous females in a high percentage of cases.—H. Briggs: Graphical classification of carbonaceous minerals: the place of the constituents of common coal. Reference was made to the method of classification of carbonaceous minerals developed in a previous paper read in March 1931. Making use of a considerable number of published analyses, the method is applied to each of the constituents of coal (vitrain, durain, and fusain) in turn. The resulting charts show the relative state of evolution of these components in any seam. Generally speaking, the fusain of any given bituminous coal is more advanced in rank than the other components. With an anthracite, however, the disparity in rank is less, the vitrain having caught up with the fusain, and having sometimes, indeed, become the more anthracitic of the two.—A. C. Aitken: On the orthogonal polynomials in frequencies of type *B*. Neither of the two types of series which are commonly used to represent probability or statistical frequency, the so-called series of type *A* and type *B*, is free from irregularity in the order of magnitude of its terms. In 1928, C. V. L. Charlier conjectured that in the case of type *A* this defect might be removed by expressing the logarithm of frequency as a series of Hermite polynomials. The correctness of this was confirmed by Dr. A. Oppenheim and the present author in 1931. An analogous procedure is now shown to be valid for the case of type *B*.—D. M. Y. Sommerville: Isohedral and isogonal generalisations of the regular polyhedra. An isohedral polyhedron means one whose faces are all congruent or mirror images, and an isogonal polyhedron one whose vertices have equal corresponding plane angles and dihedral angles. A detailed examination is made of all isohedral or isogonal polyhedra, in Euclidean and non-Euclidean geometry, which are isomorphic with the five regular polyhedra. Of special interest are the isohedral icosahedron and the isogonal dodecahedron, neither of which, unless it is regular, has either a circumscribed or an inscribed sphere. It is of interest also to note that, while in Euclidean geometry two rhombic hexahedra exist with the same faces, differently arranged, in non-Euclidean geometry the only hexahedron whose faces are symmetrical quadrilaterals is the regular hexahedron. Further, four different isohedral octahedra can be constructed with the same triangular faces, differently arranged.

PARIS *

Academy of Sciences, Dec. 28.—Mlle. Lucienne George: The relations of the Gnetales with the Dicotyledons and the Gymnosperms.—E. Miège: The taxonomic values of the leaf characters of cereals.—H. Colin and M. Quillet: The composition of the jelly of *Auricularia mesenterica*. Hydrolysis gave mannose and arabinose. No ketonic sugar was found.—Marcel Chopin: Study of commercial colloidal complexes: application to indiarubber. A detailed account of a method of preparing rubber films for mechanical testing: concordant and repeatable measurements can be obtained with films prepared by the method indicated.—A. Damiens and Mlle. S. Blaignan: The normal bromine in plants: food grains, wheat, bread. The seeds of about twenty plants were examined, and bromine was present in all, with the exception of rice and beans, in which the halogens are present in traces only. The ratio of bromine to chlorine was not found to be constant, but varied from 85×10^{-3} (lentils) to $2{\cdot}8 \times 10^{-3}$ in wheat.—J. André Thomas: Researches on the obscure vesicles of *Sipunculus*. The reproduction by budding. The observations described lead to the

* Continued from p. 215.

conclusion that the vesicles of *Sipunculus* are special stages in the evolution of a new parasite, which give rise by budding to young vesicles.—**Alphonse Labbé**: The food factor in the specific coloration of eolidians.—**Raymond Hovasse**: Radiolaria and Silicoflagellæ.—**Mézincesco**: The rôle of the non-essential amino-acids in the partial supply of the specific endogenous nitrogen consumption.—**F. Marceau** and **L. Acolat**: General considerations on the circulation of the venous and arterial blood in the three-cavity hearts of vertebrates and the measurement of the degree of their admixture.—**F. Maignon** and **M. A. Chahine**: The nitrogen balances in white rats submitted to egg albumin fat and to egg albumin glucide regimes. Fats exert a favourable effect on nitrogen metabolism and result in a better nutritive yield of the proteins from the point of view of proteosynthesis.—**A. Leulier** and **F. Postic**: The influence of nitration and of amination on the physical and physiological properties of methylphenylmalonyl urea (rutonal) and of ethylphenylmalonyl urea (gardenal or luminal). The introduction of the nitro or amino group into the benzene nucleus of hypnotics of the phenylmalonyl urea group lowers the partition coefficient between water and olive oil. The hypnotic effect is also lowered.—**Georges Bohn** and **Mme. A. Drzewina**: The morphogenic action of betaine on the eggs and larvæ of the sea-urchin.—**Ch. Hervieux**: The search for indoxyl (indican) in the milk of cows and goats. Some authors do not admit that indoxyl colouring matters can, in the normal state, pass into the milk. The experiments described, carried out on twenty-five specimens of normal milk, gave positive reactions for indican with thymol in every case.—**Edouard Chatton** and **André Lwoff**: The conception of an apostome ciliate (Fœttingeriideæ and Opalinopsideæ). Proofs of its validity.—**E. Fernbach**: The period of preservation of solutions of tuberculin. A solution of tuberculin (dilution $\frac{1}{8}$) made up in 1907 was proved to be active in 1913, nearly six years later. A further test of the same solution made twenty-five years after dilution showed that it had not lost its activity. The solution was kept in sealed sterilised tubes, at 20° C., and in the dark.—**Jean Régnier** and **Robert David**: Contribution to the study of microbial multiplication. The modifications in the composition of different liquid culture media brought about by the microbial increase (pyocyanic bacillus). It does not appear that the arrest of growth is due to exhaustion of the food supply. The chemical changes produced in the media are not proportional to the bacterial growth.

SYDNEY

Linnean Society of New South Wales, Oct. 28.—**Lilian Fraser**: The reaction of *Viminaria denudata* to increased water content of the soil. The shrub can survive a condition of soil saturation for extended periods and reacts to this condition by the production of both upright and 'knee-bend' pneumatophores, and by the production of a secondary aerenchyma in submerged roots, which is cut off from a phellogen arising in the pericycle, replacing the cork layers of the normal root.—**F. A. Craft**: The physiography of the Shoalhaven River valley. (6) Nerriga. Consideration is given to the origin and significance of the drift, and a special study of land forms in various strata is made. The valley types are dated with reference to late Tertiary basalt, and it is hoped that this will permit the identification of similar forms in places from which basalt is absent.—**A. H. S. Lucas**: Notes on Australian marine algæ (6). Description of six species of marine algæ as new; they belong to the genera *Gelidium*, *Pterocladia*, *Nitophyllum*, *Champia*, *Lessonia*, and *Caulerpa*.

Forthcoming Events

Societies

FRIDAY, FEBRUARY 12

ROYAL ANTHROPOLOGICAL INSTITUTE (Sociological Research Committee) (at 52 Upper Bedford Place), at 4.—Mrs. Seligman: The Method of Exhibiting Genealogical Data.—C. W. M. Hart: Is it correct to regard all Australian Tribes as on the same Economic Level?

ROYAL ASTRONOMICAL SOCIETY, at 5.—Anniversary Meeting.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. H. A. Harris: The Comparative Anatomical Aspect of Pre-Natal, Infantile, and Adult Disease in Man and Animals, with special reference to Bone Growth (2) (Hunterian Lecture).

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir John Cadman: Petroleum: A Record of Achievement in Applied Science.

MONDAY, FEBRUARY 15

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 4.—Wilfred Trotter: Hunterian Oration.

INSTITUTION OF ELECTRICAL ENGINEERS (Mersey and North Wales (Liverpool) Centre) (in Arts Theatre, Liverpool University), at 7.30.—Prof. J. K. Catterson-Smith: Everyday Uses of Electricity (Faraday Lecture).

TUESDAY, FEBRUARY 16

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Sir William Bragg: Recent Work on Crystal Analysis (2).

ROYAL SOCIETY OF MEDICINE, at 5.30.—General Meeting of Fellows.

WEDNESDAY, FEBRUARY 17

BRITISH ACADEMY, at 5.—Prof. H. J. Fleure: Archæology and Folk-Tradition (Sir John Rhŷs Memorial Lecture).

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. W. E. Le Gros Clark: The Structure and Connexions of the Optic Thalamus (1).

INSTITUTION OF ELECTRICAL ENGINEERS (Sheffield Sub-Centre) (at Royal Victoria Hotel, Sheffield), at 7.30.—J. M. Donaldson: Presidential Address.

FOLK-LORE SOCIETY (Annual General Meeting) (at University College), at 8.—Presidential Address.

THURSDAY, FEBRUARY 18

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Prof. J. B. S. Haldane: Heredity in Man (1).

FRIDAY, FEBRUARY 19

INSTITUTION OF CHEMICAL ENGINEERS (Annual Corporate Meeting) (at Hotel Victoria, Northumberland Avenue), at 12 noon.—W. A. S. Calder: Control of Industry (Presidential Address).—At 2.15.—Dr. Ezer Griffiths: Thermal Insulation.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. W. E. Le Gros Clark: The Structure and Connexions of the Optic Thalamus (2).

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Prof. C. F. Jenkin: The Mechanics of Shifting Sands.

Public Lectures

FRIDAY, FEBRUARY 12

ST. BARTHOLOMEW'S HOSPITAL MEDICAL COLLEGE, at 5.30.—Dr. L. Findlay: The Feeding and Nutritional Disease of the Infant (3).

UNIVERSITY COLLEGE, at 5.30.—Prof. Sir Reginald Fleming Johnston: China in the Ancient World.

SATURDAY, FEBRUARY 13

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Mrs. Olwen Brogan: Town-Life in the Roman Empire.

MONDAY, FEBRUARY 15

GUY'S HOSPITAL (in Physiological Theatre), at 5.—Dr. A. E. Barclay: The Use of X-Rays in Physiological Investigations: The Mechanism of Swallowing.

UNIVERSITY OF LEEDS (in Chemistry Lecture Theatre), at 5.15.—Prof. P. Kapitza: Phenomena in Strong Magnetic Fields.

KING'S COLLEGE, LONDON, at 5.30.—Prof. S. H. Hooke: The Myth and Ritual of the Old Testament and the Culture Patterns of the Ancient East: Traces of Early Myth and Ritual in Canaan.

TUESDAY, FEBRUARY 16

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL, at 5.15.—Prof. A. E. Boycott: Hypertrophy and Atrophy (2).

INSTITUTE OF INDUSTRIAL ADMINISTRATION (at Institute of Hygiene), at 6.30.—E. S. Byng: Elimination of Waste in Industry.

WEDNESDAY, FEBRUARY 17

ROYAL INSTITUTE OF PUBLIC HEALTH, at 4.—Dr. A. R. Neligan: The Organisation of Treatment for Industrial Rheumatism.

KING'S COLLEGE, LONDON, at 5.15.—Prof. J. Holland Rose: The Mediterranean in Ancient History (5): The Mediterranean Empire and its Influence on Civilisation.

BELFAST MUSEUM AND ART GALLERY, at 8.—Dr. R. H. Hunter: The Wonders of the Human Body.

THURSDAY, FEBRUARY 18

UNIVERSITY OF LEEDS (in Physics Lecture Theatre), at 2.30.—Sir William Bragg: The Laboratory and the Citizen.

UNIVERSITY COLLEGE, at 5.30.—Prof. E. G. Gardner: Campanella and the City of the Sun.—Sir J. J. Thomson: Physical Lines of Electrical Forces and their Application to the Interpretation of the Electromagnetic Field (1).

MEDICAL SOCIETY OF LONDON.—Dr. J. D. Rolleston: Benjamin Ward Richardson, his Life and Work (Chadwick Lecture).

FRIDAY, FEBRUARY 19

UNIVERSITY COLLEGE, at 5.30.—Sir E. Denison Ross: The Unification of Asia under the Monguls.

ROYAL VETERINARY COLLEGE, at 5.30.—T. M. Doyle: Diseases of Birds due to Filterable Viruses (1).

SATURDAY, FEBRUARY 20

MATHEMATICAL ASSOCIATION (London Branch) (at Bedford College for Women), at 3.—Discussion of Members' Topics.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—H. N. Milligan: Nature Studies on the Sussex Coast.

Official Publications Received

BRITISH

Air Ministry: Aeronautical Research Committee: Reports and Memoranda. No. 1400 (Ae. 521—T. 3131): Experiments on a Model of *R.101*, with Applications to determine the Steady Motion. By Dr. R. Jones and A. H. Bell. Pp. 31+17 plates. 1*s.* 9*d.* net. No. 1417 (Ae. 538—T. 3118): Scale Effect on High Tip Speed Airscrews. By A. S. Hartshorn and Dr. G. P. Douglas. Pp. 17+9 plates. 1*s.* net. No. 1425 (Ae. 545—T. 3149): Models for the Determination of Critical Flutter Speeds. By Dr. W. J. Duncan. Pp. 5. 4*d.* net. (London: H.M. Stationery Office.)

Department of Agriculture: Straits Settlements and Federated Malay States. General Series, No. 6: Technical Reports for the Year 1930. Pp. iii+84. 50 cents. General Series, No. 7: Reports of Agricultural Field Officers for the Year 1930. Pp. iv+116. Classified List of the Principal Original Articles published in the Agricultural Bulletin of the F.M.S. and S.S. and the Malayan Agricultural Journal for the Period 1913 to 1930 (Vols. 1 to 18). Pp. iii+35. (Kuala Lumpur.)

Department of Scientific and Industrial Research. Report of the Water Pollution Research Board for the Year ended 30th June 1931; with Report of the Director of Water Pollution Research. Pp. iii+39. (London: H.M. Stationery Office.) 9*d.* net.

Proceedings of the Society for Psychical Research. Part 122, Vol. 40, January. Pp. 105-164. (London.) 4*s.*

The Proceedings of the Physical Society. Vol. 44, Part 1, No. 241, January 1. Pp. viii+113. (London.) 7*s.* net.

Department of Scientific and Industrial Research. Report of the Building Research Board; with the Report of the Director of Building Research for the Year 1930. Pp. viii+136. (London: H.M. Stationery Office.) 2*s.* 6*d.* net.

The Scientific Proceedings of the Royal Dublin Society. Vol. 20 (N.S.), No. 15: Cytological Studies of Potato Plants affected with certain Virus Diseases. By Dr. Phyllis Clinch. Pp. 143-172+plates 4-8. 5*s.* Vol. 20 (N.S.), No. 16: The Effect of an Insufficient Supply of Vitamin D on the Growth of the Skeleton and Internal Organs of Chickens. By E. J. Sheehy and Miss K. Sheil. Pp. 173-179+1 plate. 1*s.* (Dublin: Hodges, Figgis and Co.; London: Williams and Norgate, Ltd.)

Journal of the Royal Microscopical Society. Series 3, Vol. 51, Part 4, December. Pp. xvi+347-511. (London.) 10*s.* net.

Economy Advisory Council. Committee on the Mineral Content of Natural Pastures. Seventh Report. Pp. 17. (London: H.M. Stationery Office.) 3*d.* net.

Empire Cotton Growing Corporation. Report of the Executive Committee to be submitted to the Meeting of the Administrative Council on January 21st, 1932. Pp. 10. (London.)

Department of Scientific and Industrial Research: Forest Products Research. Leaflet No. 6: Dry Rot in Buildings—Recognition, Prevention and Cure. Pp. 5. (London: H.M. Stationery Office.)

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 53: The Flying Fox (*Pteropus*) in Australia. By F. N. Ratcliffe. Pp. 81. Bulletin No. 54: Investigations on "Spotted Wilt" of Tomatoes, 2. By J. G. Bald and Geoffrey Samuel. Pp. 24. (Melbourne: H. J. Green.)

FOREIGN

Field Museum of Natural History. Geological Series, Vol. 6, No. 1: The Auditory Region of the Toxodontia. By Bryan Patterson. (Publication 305.) Pp. 27. (Chicago.) 25 cents.

Ministry of Agriculture, Egypt: Technical and Scientific Service. Bulletin No. 107: The Occurrence of the "White Rot" of Onion (*Sclerotium cepivorum*, Berk.) in Egypt. By Dr. R. M. Nattrass. Pp. ii+9+9 plates. 3 P.T. Bulletin No. 117: On the Biology of *Chrysomphalus ficus* Ril. (Hem., Cocc.) with Suggestions on the Control of this Species in Egypt. By Prof. Dr. H. Priesner. Pp. 20. 2 P.T. (Cairo: Government Press.)

Ministry of Public Works, Egypt: Physical Department. The Nile Basin. Vol. 1: General Description of the Basin, Meteorology, Topography of the White Nile Basin. By Dr. H. E. Hurst and Dr. P. Phillips. (Physical Department Paper No. 26.) Pp. xii+144+157 plates. (Cairo: Government Press.) 50 P.T.

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft. 112 Jahresversammlung vom 24 bis 27 September 1931 in La Chaux-de-Fonds. Pp. 438. (Aarau: H. R. Sauerländer und Co.)

U.S. Department of the Interior: Geological Survey. Bulletin 836-A: Mineral Industry of Alaska in 1930 and Administrative Report. By Philip S. Smith. (Mineral Resources of Alaska, 1930.) Pp. ii+115+14a. 20 cents. Bulletin 836-B: Notes on the Geography and Geology of Lituya Bay, Alaska. By J. B. Mertie, Jr. (Mineral Resources of Alaska, 1930.) Pp. ii+117-135. 5 cents. Professional Paper 170-A: Glaciation in Alaska. By Stephen R. Capps. (Shorter Contributions to General Geology, 1931.) Pp. ii+8+2 plates. 15 cents. Professional Paper 170-C: A Miocene Flora from Grand Coulee, Washington. By Edward Wilber Berry. (Shorter Contributions to General Geology, 1931.) Pp. ii+31-42+plates 12-13. 10 cents. Water-Supply Paper 705: Surface Water Supply of the United States, 1930. Part 10: The Great Basin. Pp. v+92. 20 cents. (Washington, D.C.: Government Printing Office.)

Division of Fish and Game of California. Fish Bulletin No. 32: The California Halibut (*Paralichthys californicus*) and an Analysis of the Boat Catches. By G. H. Clark. (Contribution No. 109 from the California State Fisheries Laboratory.) Pp. 52. Fish Bulletin No. 33: Fishing Methods for the Bluefin Tuna (*Thunnus thynnus*) and an Analysis of the Catches. By S. S. Whitehead. (Contribution No. 110 from the California State Fisheries Laboratory.) Pp. 32. Fish Bulletin No. 34: Salmon of the Klamath River, California. 1: The Salmon and the Fishery of Klamath River; 2: A Report on the 1930 Catch of King Salmon in Klamath River. By John O. Snyder. Pp. 130. (Terminal, Calif.: California State Fisheries Laboratory.)

University of California Publications in American Archaeology and Ethnology. Vol. 28, No. 5: Wintu Myths. By Cora Du Bois and Dorothy Demetracopoulou. Pp. 279-403. (Berkeley, Calif.: University of California Press; London: Cambridge University Press.) 1.25 dollars.

Proceedings of the California Academy of Sciences, Fourth Series. Vol. 20, No. 6: The Diatoms of Sharktooth Hill, Kern County, California. By G. Dallas Hanna. Pp. 161-263+plates 2-18. 1.50 dollars. Vol. 20, No. 7: A New Subspecies of Coral Snake from Guatemala. By Karl P. Schmidt. Pp. 265-267. 15 cents. Vol. 20, No. 8: Birds and Mammals from the Kootenay Valley, Southeastern British Columbia. By Joseph Mailliard. Pp. 269-290. 25 cents. (San Francisco.)

Pratt Institute School of Science and Technology. Michael Faraday, 1791–1867: a Selected List of Books and Periodical Literature compiled by the Applied Science Department of Pratt Institute Free Library appropriate to the Centenary of Faraday's discovery of Electromagnetic Induction, September 24, 1831. Pp. 13. (Brooklyn, N.Y.)

U.S. Department of Agriculture. Miscellaneous Publication No. 127: Peafowl and their Care. By W. L. McAtee. Pp. 4. (Washington, D.C.: Government Printing Office.) 5 cents.

Smithsonian Miscellaneous Collections. Vol. 85, No. 10: Human Hair and Primate Patterning. By Gerrit S. Miller, Jr. (Publication 3130.) Pp. 13+5 plates. (Washington, D.C.: Government Printing Office.)

Bergens Museums Årsbok, 1931. Hefte 1, Naturvidenskapelig rekke. Pp. 43+50+10+47+52. Bergens Museum. Årsberetning 1930–1931. Pp. 111. (Bergen: A.-S. John Griegs Boktrykkeri.)

Ochrona Przyrody: Organ Państwowej Rady Ochrony Przyrody. Rocznik 11. Pp. 228. Państwowa Rada Ochrony Przyrody. Nr. 31: Sprawozdanie z działalności Państwowej Rady Ochrony Przyrody w Roku 1931. Napisal Prof. Dr. Władysław Szafer. Pp. 16. (Kraków: Państwowa Rada Ochrony Przyrody.)

Comité National français de Géodésie et de Géophysique: Section de Magnétisme et Électricité terrestres. Troisième mémoire sur le Nouveau Réseau Magnétique de la France au 1er Janvier 1924. Anomalies du champ magnétique terrestre en France. Par E. Matthias, Ch. Maurain, L. Eblé et Mlle. Homery. Pp. 8. (Paris: Les Presses universitaires de France.)

CATALOGUES

Watson's Microscope Record. No. 25, January. Pp. 24. (London: W. Watson and Sons, Ltd.)

Catalogue de livres anciens et modernes rares ou curieux relatifs à l'Orient. (No. 19.) Pp. 197-250. (Paris: Libr. Adrien-Maisonneuve.)