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The Zoological Record.

THE decision of the Zoological Society's council to discontinue the publication of the "Zoological Record" on the grounds of expense suggests somewhat opposing thoughts. It is generally admitted, or even strongly urged, by most workers in every branch of science that some guide to the ever-increasing flood of literature is a necessity. If this was true in 1865, when the "Zoological Record" was started, it is no less true to-day. The need, in fact, must have increased in at least the same direct ratio as the number of publications. Yet in zoology, as in geology and other sciences, these guides, records, and indexes have had a perpetual and severe struggle for life, in the course of which many have from time to time succumbed, been revived under another form, and too often again collapsed.

The "Zoological Record" itself was begun in 1865 as a publication by Van Voorst, under the editorship of Dr. Albert Günther, with a distinguished staff of recorders. The publisher paid for the printing, but the manuscript, we believe, was compiled for nothing. Mr. Van Voorst soon found the loss too great, and, though he continued as publisher, an association was founded in 1871 to guarantee the expenses. This carried on till 1887, when the Record was saved from extinction by the Zoological Society, which generously shouldered the burden and bore it unaided until the establishment of the International Catalogue of Scientific Literature. The question then arose whether the record of zoology should merely become one part in that vast scheme. Fortunately the secretary of the Zoological Society was far-sighted enough to preserve the continuity and title of the Record and the control of the Society, by inducing his council to contribute largely to the expense and to maintain its Record Committee. Consequently, when the International Catalogue failed, and when the Royal Society declined to undertake the huge expenditure on what had virtually become its sole responsibility, then zoologists still found their Record appearing—retarded and weakened, but in being and ready to resume its old strength and value whenever they themselves would provide the necessary sustenance. Unfortunately, the increased costs of production have coincided with the loss of a number of subscribers owing to the effects of war and its sequelæ. The secretary of the Zoological Society has over and over again sought in various directions to supply this loss, but has not met with any cheering response. All these facts must be remembered before we venture to blame the Society for its present decision.

When, now, we see the "Zoological Record" threatened with the fate that has overtaken so many similar publications, it is time to inquire more closely into the causes. For one thing, we note that the editorial and recording work is no longer done for the love of the science. For many years, indeed, the editor and recorders have been paid, but of late the appropriation for this purpose has grown enormously. Times, no doubt, have suffered an economic change; there are fewer people with money and leisure enabling them to work for nothing. But more of our younger workers should be inspired by the thought of service to their science, and should realise the experience and knowledge they themselves could gain by compiling a good Record. The work, too, is lightened for them. The International Catalogue introduced the system of furnishing the recorders with slips ready written, and to a certain extent this system is continued by the payment of searchers. We ought, therefore, to be getting an even better Record than we are, and we were hoping that it would have been possible before long to restore some details eliminated by the need for economy. Clearly, the greater the value the better is the prospect of selling.

So we pass from the producers to the purchasers. Here there are two points to be made. First, every worker should consider seriously whether he is prepared to devote a large proportion of his time to ransacking literature, at least that part of it which alone is accessible to him, or in default to work in a state of haphazard half-knowledge, or whether he is prepared to save his time by paying some one else a trifling wage (about a shilling a week) to furnish him with a complete analytical index to the yearly harvest of his science. Put thus, can he remain in doubt? If he is not stirred by conscience to pay himself, he can at least insist that the institution for which he works shall find the money and provide the book. But there is a second point. Admitting that there exist a few workers so exceedingly distinguished that they are furnished with complimentary copies of every paper on their subject that appears from China to Peru, this can scarcely affect the fact that most workers in pure or applied zoology are not in that easy position. The trouble with them is that, for the most part, they have never heard of the Record. We believe this statement to be no exaggeration, and we would urge the advisability of some real advertising. The occasion is favourable, for such competitors as there have been are nearly all now out of the running. One good way would be to induce university professors to instruct their pupils in the craft of bibliographic research.

What, then, is the conclusion? For thirty-six years the Zoological Society has earned the thanks and praise of zoologists for its support of this indispensable aid. But zoologists at large must now do their share if they wish this support to continue. On their side, as well as on that of the recorders, there must be a little more enthusiasm and self-sacrifice. The vessel is stranded, but with good will from all hands she can be kept afloat till the high tide returns. If the workers will give some real earnest of this good will, we cannot believe that the Society which has so long served as pilot will leave her to be broken up.

Hygiene of the Great War.

History of the Great War: Based on Official Documents. Medical Services: Hygiene of the War. Edited by Major-Gen. Sir W. G. Macpherson, Colonel Sir W. H. Horrocks, and Major-Gen. W. W. O. Beveridge. Vol. 1, pp. xii+400. Vol. 2, pp. vi+506. (London: H.M. Stationery Office, 1923.) 21*s*. net each.

THE two volumes dealing with that part of the Medical Services of the War which was concerned with preventive medicine possess great historical interest and high current value; they form an admirable example of the excellent results achievable when science is applied to practical life.

The first volume deals with general administrative problems, and comprises chapters on sanitary administration in the field, on the schools of sanitation and instruction organised to secure sanitary practice, on methods of water purification and of disposal of waste products in different countries, and on the housing and the clothing of the soldier. The second volume is concerned with food rations, with the physical test stations, the base hygienic laboratories, and with prisoners of war; these chapters being followed by special discussions on the prevention of malaria, of trench foot, of bilharziasis, of trachoma, of smallpox, and of plague, which present more vividly than the other chapters the successful conquest of science over disease.

The prevention of typhoid and paratyphoid, of typhus and of trench fever, are not included in the discussions in these volumes; but as the prevention and cure of pediculosis forms the essential element in the elimination of the last two of these diseases, the very full discussion given to the methods of disinfestation found most useful in the War fulfils the main need from the point of view of health, the clinical accounts of these diseases being given in other volumes of the history of the War. Similar remarks apply as regards scurvy and beri-beri, but on p. 73 of the second volume is an interesting statement as to the means taken to supply British and Indian troops with fresh fruit juice in Mesopotamia. In the prevention of beri-beri the addition of oatmeal and dhall to the British ration, the addition of marmite, and later, the issue of bread containing 25 per cent. of atta, were found valuable. After May 1917, following the report of Misses Chick and Hume, germinated dhall was used in outlying districts, when fresh vegetables or fruit could not be obtained.

A remarkable feature of medicine in the War was the stimulus given by war to scientific investigation. The instance already given is in point; and many other investigations were successfully carried out under the compulsion of urgent necessity. The pathogenesis of trench fever unfortunately was only fully revealed towards the end of the War; otherwise disinfestation of soldiers would have formed an even larger part of army sanitary work than it did. For details of a valuable investigation of energy expenditure in relation to food by Dr. E. P. Cathcart, chap. iv. in the second volume should be consulted. In the prevention of trench foot, success was at once attained so soon as compliance was secured with the army routine order that every man should remove his boots at least once in twenty-four hours, drying and rubbing his feet and putting on dry socks in place of those discarded.

In view of the large part borne by flies in conveying infection in the South African War, the prevention of flies in all divisions of the Army was vigorously promoted in the Great War, and the chapter devoted to this is a useful summary of the subject. The chapter on the prevention of infestation by lice, which is written by Sir W. H. Horrocks, is a masterly presentation of this important subject, including the biological facts, on knowledge of which efficient preventive measures must be based. The sixty-one pages devoted to this subject do no more than represent its relative importance in military hygiene, when we recall that Colonel Horrocks estimates that in the War 50 per cent. of the admissions to hospital from troops in the field armies were attributable to lack of personal cleanliness and to vermin. The great sanitary lesson of the South African War was that of fly prevention and satisfactory conservancy methods; the great sanitary lesson of the Great War has been that probably one-half of the disablement of our armies in the field is due to pediculosis and scabies.

Scabies was made the subject of accurate investigation at Cambridge, civilians volunteering for this purpose. These investigations showed that the infection of scabies could be conveyed by sleeping in beds previously occupied by heavily infested soldiers or by wearing their clothing. Perhaps the least satisfactory disease prevailing among soldiers, from the point of view of control, was cerebro-spinal fever; and although very specialised efforts were made to prevent its dissemination, it may be doubted whether these were successful, apart from the diminished prevalence which was secured when barracks became less crowded and an approximation towards open-air conditions became possible. There does not appear to be any justification for the belief that the segregation of contacts with cases of the disease or the chemical spraying of the throats of contacts, which was practised on a large scale, greatly influenced the course of events.

There are but few statistics of disease in these two volumes; but it is significant that whereas in the South African War, with an aggregate personnel of 530,000, 8000 men died of typhoid fever, only 266 deaths from this disease occurred in the Great War in the Western Front among British and Dominion troops, with an average strength of 1¼ millions and an aggregate of three or four times that number. The relative share of prophylactic vaccines, of purification of water, and of the sanitary disposal of waste-products in securing the remarkably low incidence of typhoid and of dysentery in the War is not discussed in these volumes; but we hope that in some other volume of the history of the War it will be possible to give details of any experiences in which one or other of these factors of prevention was absent, with the view of assessing their relative value in actual experience.

Attention is directed in Sir W. G. Macpherson's preface to the fallacious illogicality of estimating the healthiness or otherwise of troops by the ratio of deaths from disease to deaths from wounds. This ratio is evidently one between two variables: in particular the number and extent of the battles may vary. As a permissible limit of inefficiency due to sickness in an army in the field, 0·3 per cent. of strength had been accepted as a permissible limit; and this empirical standard was found in experience to be most useful in directing attention to the need for special inquiry in any unit.

The details of sanitary organisation given in vol. 1 are of importance to all practical workers, and this volume will for years form a valuable source of information. The success of the sanitary work of the Army in circumstances involving a manifold multiplication of existent machinery is one of the most striking features of the War. Some of the factors rendering this rapid addition to sanitary staffs practicable are not stated in these volumes; but it is noteworthy that the health of the troops sent abroad depended primarily on the condition of the rapidly improvised camps which were scattered throughout this country; and that the sanitary safety of these camps depended in large measure on the sanitary provisions in the districts in which they were placed, and on the active co-operation between local and central sanitary authorities and the Army authorities. The records of the Local Government Board and of local authorities show that their assistance was given whole-heartedly, and that the soldiers had the full advantage of the high general standard of civil sanitary administration in this country. Furthermore, the Army Sanitary Officers were recruited from the ranks of medical officers of health. To these facts, to the excellent Army medical organisation, to the Army schools of instruction in hygiene, and to the fact that the sanitary lessons of the South African War had been learnt, we must attribute the relative freedom from intestinal infections during the Great War. The investigations made during the War have advanced our medical and hygienic knowledge, and thus the Army will be able to repay its indebtedness to civilian sanitarians by adding to our means of preventing disease in the ordinary course of civilian life.

Radiophones.

(1) *Radio Phone Receiving: a Practical Book for Everybody.* Edited by Prof. Erich Hausmann. Pp. vii + 183 + 14 plates. (London, Bombay and Sydney: Constable and Co., Ltd., 1922.) 9*s.* net.

(2) *Direction and Position Finding by Wireless.* By R. Keen. Pp. xix + 376. (London: The Wireless Press, Ltd.; New York: Wireless Press, Inc., 1922.) 9*s.*

(3) *Wireless: Popular and Concise.* By Lt.-Col. C. G. Chetwode Crawley. Pp. 92 + 8 plates. (London: Hutchinson and Co., n.d.) 1*s.* 6*d.* net.

(4) *The Wireless Telephone: What it is, and How it Works (including Directions for Building a Simple Receiver for Wireless Telephone Broadcasts).* By P. R. Coursey. Pp. vi + 113. (London: The Wireless Press, Ltd.; New York: Wireless Press, Inc., 1922.) 2*s.* 6*d.*

(5) *Crystal Receivers for Broadcast Reception.* By P. W. Harris. Pp. 75. (London: The Wireless Press, Ltd.; New York: Wireless Press, Inc., 1922.) 1*s.* 6*d.*

(6) *Mast and Aerial Construction for Amateurs: Together with the Method of Erection and other Useful Information.* By F. J. Ainsley. Pp. 82. (London: The Wireless Press, Ltd.; New York: Wireless Press, Inc., 1922.) 1*s.* 6*d.*

(7) *The Perry Auto-Time Morse System: an Aid to the Rapid Acquirement of Speed in the Transmission and Reception of the Morse Code.* By F. W. Perry. Pp. 16. (London: The Wireless Press, Ltd.; New York: Wireless Press, Inc., 1922.) 6*d.*

A CONSTANT struggle has been going on for the last ten years between the users of the adjectives "wireless" and "radio." It is hoped that the question will be solved by international agreement. In America "radio" is in general use, but in this country it is probable that "wireless" will be used by many experts for several years to come. It is easily understood why authors who have written books on "wireless" should be loath to change, but that they should have a strong following seems odd. In our opinion, "radiophone" is a suitable contraction for "radiotelephone," and "radiophone communication" is better than "wireless telephone communication."

Whether we like it or not, there is no doubt that listening to radio broadcasting has become an everyday incident in many households. Until about November 1920 practically the only use of radiocommunication was for signalling between pairs of stations. That a message sent out from a station could be heard simultaneously at many others was generally regarded as an inherent drawback to this system of communication, except in the case of a ship in distress on the sea. In the United States radiophone broadcasting began with news items and phonograph music. The latter item was not so good as having your own phonograph. You had to be content with a record chosen by somebody else, at a time which he thought best. The stations now send out vocal and instrumental music, time-signals, accounts of sporting contests, weather and stock-exchange reports, and so on. If broadcasting is to be a success, the programmes have to be good from both the recreational and educational points of view. The quality of the speech and music reproduced by the radiophones or the loud-speaking telephone must surpass the performance of a gramophone. The programmes must be sent out daily at definite times and with absolute punctuality. Lastly, inexpensive and easily operated receiving apparatus must be readily procurable.

A development which will probably take place in the immediate future is the simultaneous transmission of different programmes. This can easily be done by using different wave-lengths. The element of choice will certainly make the broadcasting more attractive. From the programmes published in America we learn that the radiophone "cheers the hospitals," brings "church services to the home-bound" and "entertainment and news to the isolated." A claim is also made that radio broadcasting tends towards greater national and international harmony.

On the other hand, Mr. Perry in the preface to (7) advises every one to learn the Morse Code so as to listen-in to radio-telegraphic messages, which, he says, is far more interesting than broadcast radiophone concerts. In his opinion the constantly changing personal messages sent out "open up a vast field of interest, amusement, and knowledge." His book is to help the reader "to maintain a healthy interest in such a wonderful subject." It seems to us that there is room for a book on the subject of the ethics of "listening-in" to urgent personal and farewell messages from, for example, passengers on board ship. This method of obtaining interesting and amusing knowledge would not appeal to every one.

(1) Prof. Hausmann's book describes in an excellent and simple way the methods and apparatus used for receiving radiophone speech and music. Nine of the most eminent experts in America have co-operated to produce a thoroughly good book which can be readily understood without special technical knowledge.

(2) Mr. Keen's book deals not only with the general principles of direction-finding, but also with the constructional details of the installations required for shore service and for the navigation of ships and aircraft. It will be appreciated by the expert, for, although the discussion of problems is usually rather elementary, it is very thorough. The nomenclature of the subject is not yet fixed and so the author occasionally uses alternative words. We thus find the "cardioid," the "heart-shape," and the "apple" diagram of reception. Occasionally the author gets tired of writing about the "Marconi-Bellini-Tosi" system and refers to it simply as the M.B.T. system. The notes on field and nautical astronomy given in the appendix are good and will be helpful to the engineer.

(3) Colonel Crawley's little book on wireless is popular and interesting. He points out that the enthusiasm for broadcasting may have drawbacks. In the United States it is sometimes called "radio-flu." The purchase of a cheap set may lead to grievous disappointment. He gives a thoughtful discussion of the Imperial Wireless Chain.

(4) Mr. Coursey discusses the essentials of a radiophone and how it operates. He uses "wireless" and "radio" indiscriminately. The book is nicely got up and will be useful to beginners.

(5) The fifth book on our list will meet the requirements of those who desire to construct their own apparatus. A detailed description is given of a high-grade crystal receiver suitable for the reception of the broadcast concerts and radio time-signals sent out by the Eiffel Tower station in Paris. It must be remembered, however, that the concerts broadcasted by the Hague are quite inaudible in even a good crystal receiver connected with a large aerial. They can be heard only by suitable valve apparatus.

(6) Full particulars are give in Mr. Ainsley's little book for erecting various kinds of masts and aerials. Although it is not essential to possess an outside aerial with every receiving set, yet, when economy is a consideration, it is an advantage to have one. A strong 36-foot mast is shown the cost of the material for which was only 25*s*.

(7) In the last book on our list the author describes an ingenious method of learning the Morse system rapidly. This book should prove very helpful to many amateur radio-telegraphists.

Those intending to listen-in to the broadcasting must remember that even the best loud-speaking telephones appreciably distort speech and music. They cannot be used, also, unless the signals be so strong that they are uncomfortably loud on the radiophones. As a general rule, if it is desired to make signals audible in a room by means of a "loud speaker" it is necessary to add a two-valve magnifier to a set which would give comfortable hearing when used with radiophones. The two-valve magnifier itself appreciably distorts speech, thus adding to the troubles of those who listen-in.

The "Chemical" Sense.

Smell, Taste, and Allied Senses in the Vertebrates. By Prof. G. H. Parker. (Monographs on Experimental Biology.) Pp. 192. (Philadelphia and London: J. B. Lippincott Co., 1922.) 10*s*. 6*d*. net.

THE mechanism of the senses of smell and taste is apt to be unduly neglected, probably on account of the fact that in civilised man these senses do not play a large part in intellectual processes. But they bring before us some interesting problems as to the nature of receptor organs in general. It will be remembered that the object of such organs is to excite a set of nerve fibres on the incidence of some external agency of such a kind or intensity as to be unable to affect these nerve fibres directly. This is done by the production of some powerfully stimulating agent in the receptor mechanism at the terminations of these nerve fibres.

It is difficult to define satisfactorily the difference between taste and smell. If it be said that the former relates to substances in solution, whereas the latter relates to vapours, we are met with the fact that even vapours must be dissolved in the watery layer covering the olfactory cells. Moreover, the presence in fishes of a mechanism which appears to be the same as that of smell in air-breathing organisms suggests the need of some other criterion. Prof. Parker directs attention to the lipoid solubility of odorous substances and to the existence of hairs composed of lipoid material on the olfactory cells. The relation of surface tension and adsorption has also been brought into connexion with odorous properties. When we come to attempt to correlate either smell or taste with chemical composition we are met with serious difficulties.

The sense of taste is shown to include at least four distinct senses—sour, saline, bitter, and sweet. Some interesting experiments are given on p. 161, which show that the catfish, Amiurus, responds to meat juice by means of taste-buds situated on the sides of the animal. What is also significant is that the response is accompanied by "local sign," just as touch is in ourselves. The fish is aware of the position of the stimulus, turns to it, and swallows the meat. The response is absent when the nerves to the taste-buds are cut.

Prof. Parker holds that the sensations produced by various chemical irritants are to be distinguished from those of pain, although both are devoid of differentiated receptor organs and are mediated by free nerve endings. The chemical sense is said to be abolished by a smaller dose of cocaine than is the sense of pain. They have in common, however, a high threshold value, as would be expected from the nature of the structures stimulated. As the object of the sensibility is mainly to avoid injury, too great a delicacy would clearly be a disadvantage. The last chapter of the volume contains an interesting discussion on the relations between the common chemical sense and those of smell and taste. Of the three the olfactory sense is regarded as the most primitive, that of taste the most highly developed, with the common chemical sense as intermediate in evolution.

The volume is a very useful summary of our knowledge on the subject of the "chemical" senses as a whole. W. M. B.

Our Bookshelf.

Geologie in Tabellen für Studierende der Geologie, Mineralogie, und des Bergfachs, der Geographie und der Landwirtschaft. Von Prof. Dr. K. Andrée. Erster Teil. Pp. xv+96. Zweiter Teil. Pp. 97-134. Dritter Teil. Pp. 135-228. (Berlin: Gebrüder Borntraeger, 1921–1922.) Three parts, 8*s*.

THE most remarkable things about this representation in tables of matters with which the geologist has to deal are the ingenious industry of the author and the very moderate price at which the book has been so excellently produced. Whether it will appeal to students depends much on the individual frame of mind. We incline to think that the "Tabellen"—we had almost written "tabloids"—will be of most, and indeed of considerable, service in the private library, as reminding the worker of what to look for in larger and descriptive treatises. It is to be regretted that there is no index to the mass of information of an expected or unexpected nature here assembled.

The author, in view of the abundance of material, has wisely kept the classification of igneous rocks on very simple lines. The customary grading of the "fine earth" of soils is given in section B of Table 49. Prof. Andrée has directed attention to his use of graptolites and ammonites in the stratigraphical tables, and here the succession of strata in various regions is set forth under the several systems. The columns dealing with the later series naturally show far more detail than those relating to the Carboniferous and older systems. The full treatment of Cainozoic strata should go far to correct the notion of their relative unimportance that still prevails among geologists in the British Isles. This is, we fancy, the portion of Prof. Andrée's work that will be referred to most often.

Prof. Andrée in his last ten pages generously provides a list of authoritative modern works on geology, which will guide the student into more arcadian fields. With two exceptions in favour of the United States, and three of an international character, the books named are all in German, so that we miss Geikie's "Text Book," Haug's "Traité," and De Margerie's translation, virtually a revised and extra-illustrated edition, of Suess's "Antlitz der Erde." G. A. J. C.

Reinforced Concrete: A Practical Handbook for Use in Design and Construction. By R. J. Harrington Hudson. Pp. xxiv+318. (London: Chapman and Hall, Ltd., 1922.) 16*s*. net.

THIS volume is one of the very few treatises on reinforced concrete in which the properties of the materials employed, and the methods of working these materials so as to produce the finished results, receive adequate treatment. The matter is of great importance from the student's point of view; in too many instances, after a course in reinforced concrete, the impressions left in his mind are somewhat hazy, and he is apt to think that the subject is one consisting only of complex calculations. The early chapters in the book before us will go far to remove this impression. Most of the space is taken up with questions of design, both in theory and practice; the plan generally followed has been to give a general discussion of the particular problem, and then to throw the results into the form of tables and graphs so as to simplify so far as possible the practical work of the designer. The reader will find the numerous worked-out examples very helpful in gaining a knowledge of the methods of practical design. The portions dealing with monolithic design are good, and include discussions on secondary stresses and on continuous beams monolithic with columns. In developing this part of the subject the author successfully employs the equation of three moments. The London County Council reinforced concrete regulations are included in the volume, as also are extracts from the British standard specifications relating to Portland cement, and structural steel. The author is to be congratulated on his volume, which cannot fail to be of value both to engineering students and to those engaged on the practical side of structural engineering.

The Topography of Stane Street: a Critical Review of "The Stane Street," by Hilaire Belloc. By Capt. W. A. Grant. Pp. 95. (London: John Long, Ltd., 1922.) 5*s*. net.

IN his critical review of Mr. Belloc's "Stane Street," Capt. Grant has produced a valuable study of this Roman way, which, although the author pretends to offer no opinion on historical or archæological points and confines himself to questions of topography, is of no inconsiderable interest to archæologists and students of Roman Britain. His criticism of Mr. Belloc is that, while an adept in map reading, his lack of familiarity with the principles of surveying for map construction has led him into numerous errors in tracing the alignments of Stane Street from Chichester to the site of Old London Bridge, sixty yards east of the modern bridge.

Mr. Belloc's theory is that there were four great limbs or sections covering respectively the ground from Chichester (east gate) to Pulborough Bridge, from Borough Hill to Leith Hill, from Leith Hill to Juniper Hill, and from Juniper Hill to the southern end of London Bridge. Capt. Grant examines each of these in detail and demonstrates the errors, while in a further chapter he indicates the true alignments and discusses the general principles upon which Stane Street would appear to have been planned. Capt. Grant is commendably precise in his criticisms, and in two appendices gives long lists, with references, of "Errors due to carelessness or Printers' Errors," and "Errors due to Miscalculation and mis-statements arising therefrom."

British Museum. Guide to the Maudslay Collection of Maya Sculptures (Casts and Originals) from Central America. Pp. 94+8 plates. (London: British Museum, 1923.) 1*s*. 6*d*. net.

To the small but select band of Americanists in this country it has always seemed little short of a scandal that the Maudslay Collection of Maya Sculptures, after being on exhibition for a short time at the Victoria and Albert Museum, should have been consigned to store, where it has remained for thirty years. Its rescue and display in the galleries of the British Museum pays a tardy tribute to Dr. A. P. Maudslay's pioneer researches and his enthusiastic efforts to preserve a faithful record of the remarkable artistic skill and culture of the ancient inhabitants of Central America. This collection of casts and originals was made by Dr. Maudslay, entirely at his own expense, between the years 1881 and 1894, when he made no less than seven journeys to Central America, visiting the principal sites in Yucatan, Honduras, and Guatemala.

The preparation of the guide to the collection has been in the competent hands of Mr. T. A. Joyce, who, in addition to a detailed description of the exhibits, has written an introduction dealing with the main characteristics of Maya culture and, in particular, with their hieroglyphic and chronological systems. It contains exactly the information necessary to enable the uninstructed visitor to the gallery to appreciate the most striking features of this ancient semi-civilisation.

Flora of the Presidency of Madras. By J. S. Gamble. Part 5: Ebenaceæ to Scrophulariaceæ. (Published under the authority of the Secretary of State for India in Council.) Pp. 769–962. (London: Adlard and Son and West Newman, Ltd., 1923.) 10*s*. net.

THE present part of Mr. Gamble's Madras flora is on the same lines as previously issued parts. The family Ebenaceæ is completed, with an enumeration of the 24 species of Diospyros, several of which are large trees yielding a black heartwood, or ebony; and the treatment of the families of gamopetalous dicotyledons follows in the sequence usually adopted in the British Colonial floras. The principal families are Apocynaceæ, Asclepiadaceæ, and Convolvulaceæ, and the part concludes about half-way through Scrophulariaceæ. Solanaceæ is poorly represented, but in this family, as in Apocynaceæ, several South American genera, introduced in cultivation, have run wild. Mr. Gamble enumerates eight species of Strychnos, including *Nux vomica*, the source of strychnine, and another species, the seeds of which yield the alkaloid brucine; a third species, *S. potatorum*, derives its name from the fact that the seeds are used to clear muddy water. Of the Convolvulaceæ, the genera Argyreia and Ipomœa supply many showy-flowered climbers; *I. Batatas*, sweet potato, is in common cultivation as a vegetable.

Coal and Allied Subjects: a Compendium of the First Ten Bulletins issued by the Lancashire and Cheshire Coal Research Association. By F. S. Sinnatt. Pp. v+205. (London: H. F. and G. Witherby, n.d.) 15*s*. net.

MR. SINNATT and his collaborators have prepared a compendium of the first ten bulletins issued by the Lancashire and Cheshire Coal Research Association, and the intention of the publication is "to enable those engaged in the Coal Industry and others to share the knowledge gained in carrying out the work." The bulletins have been well worth collecting and issuing together in this form, which will facilitate ready reference. They vary in content from such a general subject as "Notes of Ten Introductory Lectures on Organic Chemistry, with Special Reference to Coal" (condensed into 32 pages) to the highly specialised brief bulletin on "Hoo Cannel." One of the most interesting describes the examination of the inorganic constituents of coal which deals with those ash inclusions known as ankerites, while "Coal Dust and Fusain" indicates another line of work with which Mr. Sinnatt has identified himself. No very fundamental problems of fuel technology have been attacked, and some of the matter is not original, being simply collected in the bulletins for the convenience of the Research Association, but it is a record of useful work. J. W. C.

The Phase Rule and its Applications. By Prof. Alexander Findlay. (Text-books on Physical Chemistry.) Fifth edition. Pp. xvi+298. (London: Longmans, Green and Co., 1923.) 10*s*. 6*d*. net.

THE fifth edition of Prof. Findlay's book on the phase rule differs from previous editions in that the whole volume has been re-set, so that in spite of containing additional matter there is a substantial reduction in the number of pages. In the new edition the iron-carbon diagram has been altered in order to include the δ form of iron which appears when the pure metal is heated to 1400° or to a somewhat higher temperature in presence of carbon; the β form of iron has also been eliminated as differing only in magnetic properties from α-iron or ferrite. New material has also been introduced in connexion with the allotropy of sulphur and phosphorus, in view of the fact that these elements can give rise to pseudo-binary systems. In the later chapters of the book, additional space has been devoted to the mineral-forming systems, including both the aqueous deposits of the Stassfurt salt beds and the igneous calcium aluminium silicates.

Letters to the Editor.

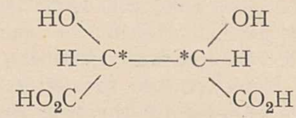
[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Molecular and Crystal Symmetry.

THE relation between the symmetry of a crystal and that of the component molecules has been recently discussed by G. Shearer (Proc. Phys. Soc., 1923, vol. 35, p. 81), who, unknowingly following the same train of thought, has arrived at the conclusion, previously stated by Fedorov (*Zeits. Kryst.*, 1912, vol. 52, p. 22), that a crystal obeys what may be termed a principle of conservation of symmetry. Thus, if n be the "symmetry number" of the structural unit or parallelepipedal brick (the number of identical or enantiomorphously related asymmetric parts into which it is subdivisible), m the number of molecules it contains, and p the symmetry number of each molecule, then $n/m=p$, or alternatively $pm=n$, *i.e.* the symmetry of the individual molecules multiplied by their number gives the symmetry of the crystal. If the formula be correct no symmetry is dissipated, the whole of the molecular symmetry being taken up by the crystal. Now, so far as Fedorov was concerned, the matter was purely speculative, for the X-ray method had only just been discovered and its exact meaning was still obscure, but Shearer has gone a step further by collecting X-ray data in support of the principle (or "Shearer's rules"), with the result that it has been provisionally adopted by Sir W. H. Bragg (Journ. Chem. Soc., 1922, vol. 121, p. 2766) as a working hypothesis in the interpretation of X-ray measurements. As I think the various considerations advanced by Shearer are inconclusive, and are already leading to very questionable conclusions concerning the stereochemical formulæ of certain aromatic compounds, I would here submit the Fedorov-Shearer principle to a brief discussion.

It is self-evident that any real vindication of the principle involves a knowledge of all the three terms p, m, and n of the formula. Now the last two quantities are relatively easily determined, but the molecular symmetry p is a much more difficult matter, for it implies a determination with a tolerable degree of accuracy of the position of every atom in the structure, and as such difficulties have not yet been overcome in the case of such complicated compounds as the benzene, naphthalene, and anthracene derivatives investigated by Sir W. H. Bragg, it is evident that the field for testing the principle is very restricted. As a matter of fact, the evidence adduced by Shearer is very scanty, consisting as it does of the demonstration that in no known case is $m>n$, followed by the statement that if certain values of p be allowed, then all the crystals can be brought into line with the principle. It must be noted that there is no experimental evidence in favour of these special p-values (which are, then, really postulated), and that most of them are not what one would expect from chemical knowledge (unless, of course, the molecular configuration in the crystal has not the same symmetry as it has in solution). Thus, crystal molecules of α- and β-naphthol, resorcin, benzoic, salicylic, and phthalic acids are all held to be asymmetric, from which it is to be inferred that the crystals contain two kinds of molecules in the manner of racemic acid. Then, again, naphthalene is held to have no plane of symmetry, and so on.

There is, however, one organic compound for which all the three terms p, m, and n have been reasonably well established, namely, the ordinary tartaric acid recently investigated by W. T. Astbury (Proc. Roy. Soc., 1923, vol. 102, p. 506). This is apparently held to conform with the principle, but as I do not agree with Messrs. Shearer and Astbury that the molecule is asymmetric, the case calls for a brief examination. The acid has long been known to have the formula



in which the two carbon atoms marked out by asterisks are the so-called asymmetric carbon atoms, *i.e.* atoms surrounded by four different groups in an asymmetric tetrahedral manner (the four groups being in each case H, OH, CO_2H, and CHOH . CO_2H). If a three-dimensional model be constructed according to the above scheme, it will be found to take three forms, depending on the way in which the duplicated groups H, OH, CO_2H are arranged about the main stem, C*——*C. One form is identical with its mirror-image (Pasteur's *meso* acid); the other two are non-identical mirror-images of each other (enantiomorphous) and represent the ordinary *dextro* acid of commerce and Pasteur's rare *laevo* acid respectively. It is the *d*-acid that is under examination, but the same will hold for the *l*-acid. If we inspect the model for symmetry we shall find a twofold (digonal) axis somewhere or other in the plane normal to the central stem, no matter how we may have previously affected the relative positions of the two ends by rotating one against the other (about the main stem). It may be added, parenthetically, that Astbury arbitrarily limits his discussion of the stereochemical model to six such positions, but in every case the molecular configuration of tartaric acid in the liquid or dissolved condition is not asymmetric (as generally described).

With regard to the state of the molecule in the crystal, a study of Astbury's paper leads me to the conclusion that the molecule is still symmetrical. The statement that "one-half of the ordinary tartaric molecule behaves exactly like the other half and is indistinguishable from it"; the pains that seem to have been taken to preserve this parity in allocating the various atoms within the structure; and, finally, the evidence of the numerous figures, all go far to counteract the impression created by Astbury's use of the term "asymmetric molecule." It seems as if the unobtrusive molecular twofold axis (normal to Astbury's "dumb-bell axis") has been overlooked. If this is so, then the state of affairs in a crystal of tartaric acid can be described as follows. The structure is not simply built up of a single space-lattice arrangement, with the molecular axes uniting to create the symmetry axis of the crystal, but is constructed of a pair of molecular lattices, mutually interpenetrating, the office of the second being to restore the symmetry lost by a refusal of the crystal to recognise molecular symmetry. As all the molecular symmetry is wasted, the Fedorov-Shearer principle is infringed to the utmost possible limit.

The above exhausts the material at present available for any practical discussion of the symmetry principle; for the numerous inorganic crystals reviewed by Shearer are evidently not put forward as proofs, but rather as contingent illustrations of the way in which the principle serves to limit the positions of the electrons in certain atoms. The conclusion must therefore be drawn that the principle has not been established. On the other hand, I am not disposed to attach too much weight to the evidence against the principle furnished by tartaric acid for the following reason. The object of Astbury's investigation was to explore the connexion between optical activity and enantiomorphism, and it was therefore necessary to choose a substance of relatively complicated composition. The crystals of tartaric acid are much too involved for any effective test of the symmetry principle. It is, for example, by no means certain that a slight deformation of the symmetrical crystal molecule into an asymmetric form could be detected by the X-ray method, and yet this deformation would be enough to substantiate the principle so far as tartaric acid is concerned.

It seems to me, therefore, that the whole question is still open, and that the suitable choice of material for an eventual test is worthy of a careful consideration. Such aromatic compounds as those under investigation for other purposes by Sir W. H. Bragg would seem to be unsuitable, for they are so complicated that the positions of the individual atoms cannot at present be deduced from the measurements; consequently, the shape and symmetry of the molecule have to be assumed. The compounds should rather belong to the simplest order of molecular structure; a molecule containing one atom of carbon is much better than one containing two. Hydrogen should be avoided, as it cannot be placed by the X-ray method. There should be as few kinds of atom as possible, for the quantitative connexion between atomic weight or number and reflection intensity is, perhaps, not too well known. The symmetry of the crystal should be beyond reproach, and it should be part of the investigation to assure it, since as a rule the crystallographer does not take the necessary trouble to determine the class of symmetry. Perhaps a suitable commencement might be made on carbon tetrabromide, CBr_4, the corresponding iodide and possibly hexachloro- and hexabromo-ethane (if these are not already too complicated). Such compounds have the advantage that the carbon content is almost negligible (being much less than the average percentage of hydrogen in organic compounds), and the X-ray effect of the carbon atom might therefore be neglected as a first approximation, the investigation being, as it were, simplified to that of a solidified bromine (or iodine) in which the halogen atoms are limited stereochemically by the insignificant carbon atom. Moreover, the dimorphism of the tetrabromide (monoclinic at ordinary temperatures and cubic above 49°) might afford information on the extent to which the molecular configuration changes with change of crystal structure.

Closely related with the above compounds are others of the same simple chemical type. Tin tetraiodide, SnI_4, for example, might give interesting results, since from the X-ray point of view the investigation might be regarded as that of an element (by virtue of the approximate equality in atomic number of tin and iodine), while from the chemical point of view one can be quite certain it is a compound (though whether the grouping of iodine atoms is tetrahedral is not so well grounded as in the case of a carbon compound). Work on such simple compounds as these might possibly establish the Fedorov-Shearer principle, and so be of assistance in the study of more highly developed carbon compounds.

T. V. BARKER.

University Museum, Oxford,
April 10.

Martini's Equations for the Epidemiology of Immunising Diseases.

E. MARTINI, in his "Berechnungen und Beobachtungen zur Epidemiologie und Bekämpfung der Malaria" (Gente, Hamburg, 1921), sets up a system of differential equations to represent the presumptive course of events in the development of an endemic in which recovery is accompanied by acquired immunity. He adopts the notation:

u = fraction of population affected with the disease, and infective.

i = fraction of population *not* available for new infection (immune or already affected).

$(1-i)$ = fraction of population *available* for new infection.

p = fraction of population newly affected, per unit of time.

q = fraction of affected population that ceases to be so, per unit of time, by recovery or by death.

m = fraction of immune population which loses immunity or dies, per unit of time.

α = infectivity (a proportionality factor).

Martini puts the new infections, p per unit of time, per head of population, proportional both to the infective fraction u of the population, and also to the fraction $(1-i)$ of the population *available* for new infection, so that $p=\alpha u(1-i)$, and accordingly writes his equations:

$$\frac{du}{dt}=\alpha u(1-i)-qu=(\alpha-q)u-\alpha ui, \quad . \quad . \quad (1)$$

$$\frac{di}{dt}=\alpha u(1-i)-mi=\alpha u-mi-\alpha ui. \quad . \quad . \quad (2)$$

Martini remarks that these equations cannot be integrated in finite terms. They are of a type discussed by the writer elsewhere (*American Journal of Hygiene*, January Supplement, 1923). Their solution in series is

$$u=P_1e^{(\alpha-q)t}+P_2e^{-mt}+P_{11}e^{2(\alpha-q)t}+P_{22}e^{-2mt}+ \ldots \quad (3)$$

$$i=Q_1e^{(\alpha-q)t}+Q_2e^{-mt}+Q_{11}e^{2(\alpha-q)t}+Q_{22}e^{-2mt}+ \ldots \quad (4)$$

From this it is seen that:

(1) The equilibrium at the origin $(u=i=0)$ is stable if, and only if, $\alpha<q$. When this condition is satisfied, the disease will die out.

(2) The solution near the origin cannot take on oscillatory form, since $(\alpha-q)$ and m are necessarily real quantities.

There is, however, another equilibrium (as pointed out by Dr. Martini), namely, at

$$u=\frac{m(\alpha-q)}{\alpha q}=U, \text{ say}, \quad . \quad . \quad . \quad (5)$$

$$i=\frac{\alpha-q}{\alpha}=I, \text{ say}. \quad . \quad . \quad . \quad . \quad (6)$$

This has a real meaning if and only if $\alpha>q$, that is to say, just in that case in which the equilibrium at the origin is unstable; at the same time, in the neighbourhood of $u=U$, $i=I$, we have again a solution—

$$(u-U)=P'_1e^{\lambda_1t}+P'_2e^{\lambda_2t}+P'_{11}e^{2\lambda_1t}+ \ldots \quad (7)$$

$$(i-I)=Q'_1e^{\lambda_1t}+Q'_2e^{\lambda_2t}+Q'_{11}e^{2\lambda_1t}+ \ldots \quad (8)$$

where

$$\lambda=-\tfrac{1}{2}\left\{\frac{\alpha m}{q}\pm\sqrt{\frac{\alpha^2m^2}{q^2}-4(\alpha-q)m}\right\}. \quad . \quad (9)$$

We need here give no further consideration to the case $\alpha<q$, since the second equilibrium has no real existence in this case, and the first equilibrum was found to be stable, the disease dying out.

In the other alternative, namely, $\alpha > q$, we have two cases to distinguish :

$$(1) \quad . \quad . \quad . \quad . \quad . \quad (\alpha - q) < \frac{\alpha^2 m}{4q^2}.$$

In this case λ_1 and λ_2 are both real and negative. The equilibrium at U, I is stable, the disease will become definitely established, if once started. The approach to equilibrium is aperiodic, asymptotic.

$$(2) \quad . \quad . \quad (\alpha - q) > \frac{\alpha^2 m}{4q^2}, \quad \text{or} \quad \frac{m}{q} < 4\frac{q}{\alpha}\left(1 - \frac{q}{\alpha}\right).$$

In this case λ_1 and λ_2 are complex, with negative real parts. The equilibrium at U, I is still stable, but will be approached by a periodic process of damped oscillations.

It may be remarked that a solution can still be given if the coefficients α, m, q, which have here been treated as constants, are regarded as periodic or even as general functions of the time. However, the numerical evaluation of the coefficients appearing in the solution then becomes very onerous. It will suffice, on this point, to refer to the pertinent mathematical literature, as, for example, Picard, " Traité d'Analyse," 1908, vol. 3, pp. 187, 188, 194, 197; Goursat, " Traité d'Analyse," vol. 2, 1918, pp. 482, 498.

ALFRED J. LOTKA.

Johns Hopkins University.

The Cause of Anticyclones.

IF space permits, I should like to reply to one or two points in the letter contributed by Mr. W. H. Dines to NATURE of April 14, p. 495.

(1) In the first place, when one is dealing with two different sorts of air, probably of unequal frequency of occurrence, it appears to me to be unsafe to depend very greatly on comparison with mean values derived from all cases considered *en masse*. Has not the Bjerknes theory been elaborated as the result of an attempt to deal with the problem of atmospheric circulation on the assumption that discontinuities might exist, and that therefore—as other methods would probably fail to reveal them—only close study of individual cases could hope to succeed?

Apart from this, Mr. Dines deals with departure of temperature from the mean for the *height* and date. In the paper (Q.J.R. Met. Soc., Jan. 1923) to which reference was made in my earlier letter (NATURE of March 31, p. 429) temperature is dealt with throughout in relation to given *isobaric surfaces*. This seemed particularly desirable in the case of polar air, for a mass of such air, leaving polar regions with high velocity and low barometric pressure, may eventually find itself, with much reduced velocity and with a pressure increased by some 20 to 30 millibars, forming the surface layers of an anticyclone in temperate regions. The corresponding adiabatic increase of temperature (communication of heat from warmer seas, etc., being left out of account as being more or less common to all polar air moving southward) would be 3° to 5° F., or enough to bring the temperature at a fixed *height* up to about the mean temperature for that height. If the fifty-two cases of anticyclones referred to by Mr. Dines are considered from the point of view of normal temperature for a given pressure it will be evident that about half must be of polar air up to 1 km., and I think this is about as large a proportion as I should claim for that level. Rather more than one-fifth would then be polar up to 3 km., and so on.

(2) The question in regard to humidity is very complex; but I have always taken exception to the view that humidity (either relative or absolute) would be of much value in distinguishing between polar and equatorial air apart, that is, from its value for locating the discontinuity. In particular, polar air, in its passage over warmer seas, should have its humidity at all heights affected quite as greatly as its temperature. Equatorial air, on the other hand, is being cooled in its surface layers in the course of its northward journey, and the cooling effect does not tend to be propagated upward to any comparable extent; such factors as are at work within equatorial air tend rather to rob it of its water vapour without renewing the supply.

I do not, therefore, consider that where polar air lies under equatorial air the inversion of temperature need necessarily be associated with any particular peculiarity as to relative humidity. At the same time, the conspicuous decrease of relative humidity is well known and appears to be common, at least to all inversions in anticyclones. It may, therefore, be a natural sequel to the inversion itself, and I offer an explanation which seems to me not altogether impossible. It is that the inversion of temperature once formed acts as a non-return valve to moisture (in the same way that it almost certainly does to dust and haze in the atmosphere), and that very soon the " convectional lid " accumulates a concentration of water vapour just beneath it; the layer of air just above, on the other hand, succeeds in passing on upward or allowing to drop below the greater part of both its dust and its moisture while replenishment of these from below has ceased.

A. H. R. GOLDIE.

Wimbledon, S.W.19,
April 26.

THE reply of Mr. W. H. Dines, in NATURE, April 14, p. 495, to Major Goldie's letter, brings out very convincingly the peculiar fact that the temperature conditions of the troposphere, both in cyclones and anticyclones, are such as would rather obliterate than maintain them. Indeed, when we consider the problem of pressure distribution, we find that the conditions are generally exactly the reverse of those required by the ordinary accepted theory, except in latitudes within the tropics of Capricorn and Cancer. We are thus faced with a very striking theoretical difficulty; for the winds of the earth do not appear, in the main, to derive their force and direction from the temperature conditions at or near the earth's surface.

One of the most marked effects of surface temperature on the pressure distribution, other than the phenomena of the trade winds, is the fact that along the high-pressure belts of the tropics the pressure is greatest over the cold land masses during the winter and lowest over the heated land masses during the summer. Another clear effect of surface temperature is the fact that the North Pacific cyclone and the North Atlantic cyclone (the eyes of the North Polar cyclone) are more powerful during the summer than they are during the winter. However, we have to set against these considerations the striking facts that throughout the year the great low-pressure areas are over the frigid poles, which are not even exposed to the sun's rays during the winter, and that the high-pressure belts are near the tropics of Cancer and Capricorn, and cover the intensely-heated desert lands of the continents. To surface temperatures, on the other hand, must be ascribed the great seasonal changes of pressure and temperature which occur over the elevated areas of Asia.

When considering the theory of anticyclones and cyclones, it is better to pay attention to the great permanent features shown by the distribution of atmospheric pressure over the earth's surface. It is to these that the prevalent winds of the atmosphere are due. Small travelling cyclones are of course interesting; and, strange to say, they show the same peculiarities of pressure and temperature distribution as do the much larger permanent cyclones. Everything points to the conclusion that there is some other force at work more potent than the temperature conditions in the troposphere; and I have suggested that this force arises from differences of temperature in the upper stratosphere.

It is true that many registering balloon ascents show an isothermal condition in the lower stratosphere; but others show quite a rapid rise of temperature with increasing height. A study of these curves led me to conclude that at a height of 60 km. the temperature approaches very nearly that of the earth's surface. That such is the case a study of meteoric phenomena has demonstrated. Now if the distribution of temperature near the limits of the upper atmosphere varied with the latitude, the pressure distribution at the earth's surface would be affected. It seemed natural to suppose that such heating would be greater over the equatorial than the polar regions; but if this were so, the low-pressure areas would be in low latitudes and the high-pressure areas in high latitudes; which is not the case.

The above considerations suggested that the upper atmosphere must be hotter over the poles than it is over the equator; for, if such were the case, all our difficulties in trying to account for the pressure distribution and directions of the winds would vanish. However, there are several peculiar phenomena of the polar areas, such as the aurora borealis, which require explanation as well. This is a matter which cannot be adequately discussed in a short letter; but it is probably due to the deflexion of electrons, etc. (shot out by the sun), towards the polar areas by the earth's magnetic field.

It has been objected that my theory necessitates vertical currents in the stratosphere, which the temperature conditions would not permit. The actual temperature conditions would certainly retard the equalisation of pressure by vertical movements in the stratosphere, and this would cause it to take place mainly in the troposphere. It may be that it is this that makes it appear as though the force maintaining cyclones resided at the upper surface of the troposphere, as Mr. W. H. Dines points out in one of his papers. Indeed, the inrush due to the friction of the air with the earth's surface in a cyclone would lead to an outrush at the top of the troposphere.

It is admitted that there are difficulties in the theory which remain to be explained; but they seem less than those met with when other theories are considered.

R. M. DEELEY.

Tintagil, Kew Gardens Road,
Kew, Surrey.

Physical Literature on the Continent.

DURING the last few years it has become increasingly difficult for the universities of Central Europe to procure the scientific journals of other countries, in consequence of the calamitous depreciation of German and Austrian currencies. Such a state of things acts as a deterrent to scientific advancement in that the knowledge of work done outside only slowly and imperfectly permeates into these countries through indirect channels. Quite recently I have had two letters from continental physicists in reference to this matter, and I am anxious to bring the facts to the notice of the readers of NATURE, in the hope that something may be done to remove to some extent the difficulty which at present exists.

Prof. Benndorf, of the Physical Institute of the University of Graz, Austria, informs me that the last number of the *Philosophical Magazine* available in that city is that of July 1914. In view of the expense, it has been quite impossible for them to procure back numbers of this and other English scientific journals, or to maintain them at present, as will be realised from the fact that the equivalent in our money of the annual grant to the Physical Institute of that University amounts only to 23*s*. The unsatisfactoriness of such conditions is obvious.

As it is not difficult in the libraries of most of our university towns to procure at least one copy of the *Philosophical Magazine*, it has occurred to me that perhaps some reader of NATURE might be prepared to assist the Graz Physical Institute, by handing over his copy of the *Philosophical Magazine* to that institution say at the end of each month of issue. Such a donation would be most acceptable, and the donor may be sure of the sincere gratitude of the recipients, some of them well known in physics, such as Benndorf, Kohlrausch, and Hess.

The second letter has reference to the Physical Institute of the University of Berlin, which, for like financial reasons, is no longer in a position to purchase the *Philosophical Magazine*. Several members of this Institute, including Prof. Pringsheim, Dr. Hettner, and Dr. Laski, have suggested to me the possibility of surmounting the difficulty by an exchange of periodicals such as has already been arranged with America. They propose an exchange of the *Philosophical Magazine* as issued for either the *Zeitschrift für Physik*, *Die Naturwissenschaften*, or some other journal to be arranged upon.

If any reader of NATURE feels disposed to assist in respect of either of the above suggestions, I shall be glad if he will acquaint me of the fact, so that I may put him in touch with the Institutes referred to.

ROBERT W. LAWSON.

The University, Sheffield,
April 18.

Chloroplasts and Cells.

IN an interesting account of studies with the variegated variety of the fern *Adiantum cuneatum* in the March issue of the *Journal of Genetics*, Miss Irma Andersson shows that the prothallia all sooner or later develop whitish stripes in which the chloroplasts are pale green and only half the size of the chloroplasts in the surrounding green cells. There are no intermediates, nor does any cell contain chloroplasts of both types. The purpose of this note is to direct attention to certain facts which appear to have a bearing on this sharp segregation occurring in gametophyte tissue.

There is evidence from several sources that the size of the chloroplasts in a cell is controlled and determined by the size of the cell, or, at any rate, that whatever determines the one also controls the other. Thus in tetraploid forms of *Solanum nigrum* and tomato produced by grafting, Winkler (*Zeitsch. f. Bot.*, 8: 417-531, 1916) has shown that the chloroplasts and starch grains as well as the cells and nuclei are approximately twice their normal size. Similarly, in the tetraploid *Œnothera gigas* it has long been known (Gates, *Arch. f. Zellforsch.* 3: 525-552, 1909) that the cells and nuclei are conspicuously larger than in the parent form, and van Overeem has shown recently

(*Beih. z. bot. Centlbl.* 39:19, 1922) that the same applies to the chloroplasts and to the xanthophyll grains in the petals. Also in the experiments of Bottomley (Proc. Roy. Soc. B, 89: 481-507, 1917), on the effect of auximones in stimulating the growth of Lemna, his figures show (see pl. 22) that not only the cells and nuclei but also the chloroplasts are conspicuously increased in size.

In *Œnothera gigas* the gigantism of these structures is inherited, while in the Lemna experiments presumably it was not. Incidentally, this is an example of the same character being inherited in one case and not in another. But in its bearing on the fern chloroplasts it is interesting as showing how the cell as a whole controls the characters of its contained chloroplasts. The abrupt change from large dark to small pale chloroplasts in the fern prothallia seems to be of the nature of an "all or none" reaction in the genesis of the cell.

That such abrupt transitions do not always occur, however, is shown by certain striped varieties of maize (Randolph, *Bot. Gazette*, 73:337, 1922) in which there is a transition zone where the cells contain plastids of many intermediate sizes and depths of colour even within a single cell.

R. RUGGLES GATES.

King's College, Strand,
London, W.C.2,
April 18.

Nightingale in Uganda.

ORNITHOLOGISTS may be interested to know that in March, when in camp in the part of the Northern Province of Uganda known as West Madi, on two successive mornings I heard a nightingale singing vigorously about 8-9 A.M.: the bird did not commence at daybreak, nor did he sing at night.

From the unfinished character of the song, and the lack of fulness and richness of the notes, I suspected that the individual was a young bird which had not yet fully developed his powers.

My attention was attracted on March 13, the day I reached the camp, about 8.30 A.M., by the familiar sound, so different from that of any African bird of the locality: unfortunately, I could not see the bird in the thick bush. The spot was just such as would have been chosen by a nightingale in England: a large clump of big trees with underbush like a small copse.

The camp was Moyo, about twenty miles west of the Nile and some ten miles south of the Uganda-Sudan frontier.

I should be glad to know whether nightingales are often heard to sing south of the Sahara. I imagine that this bird was perhaps making its way northwards from its winter quarters.

G. D. HALE CARPENTER.

Uganda Medical Service, Khartoum,
April 23.

Photography of Balmer Series Lines of High Frequency.

I HAVE recently performed a simple experiment with the luminous discharge through hydrogen, which has given results of some interest.

As is well known, it is difficult in the laboratory to photograph more than the first few members of the Balmer series, although higher members are well developed in the stars and nebulæ.

Prof. R. W. Wood has shown recently that fifteen or twenty of the Balmer lines can be photographed in a specially constructed tube running under very particular conditions, but I have found that an easy way of securing what appear to be similar results is merely to evacuate the hydrogen tube to a very low point, and then to cause the discharge to pass by the use of a glowing cathode.

Under these conditions, the Balmer series is brightened relatively to the secondary series; moreover, the brightness of the higher frequency lines is enhanced.

The experiment is clearly suggested by the atomic model of Bohr.

I hope to publish a detailed account of the investigation shortly, as I am not aware of any previous experimental work along these particular lines.

R. WHIDDINGTON.

The University, Leeds,
April 21.

Mechanism of the Cochlea.

I THINK it is evident that Prof. H. E. Roaf (NATURE, April 14, p. 498) and I approach the problem of the action of the cochlea from different aspects. He says: "A variation in pressure applied to the *fenestra ovalis*, if it is to cause a movement of the basilar membrane, must cause movement of the liquids in the cochlea." Most writers on the cochlea have started with this assumption, which is fundamental for the theories of Wrightson, Lehmann, Meyer, ter Kuile, and Hurst. But it is not possible to explain in this manner the fact that sounds can be conducted through the bones of the skull, and analysed in the cochlea in the same way as air-borne sounds. The bone-conducted sounds must be conveyed through the cochlea fluids to the basilar membrane as waves of condensation and rarefaction in the fluid. The impulses thus given to the basilar membrane must set swinging the sector of the basilar membrane in tune with their frequency. It is impossible for the sector to move without setting in movement the fluid columns between the sector and the round and oval windows which constitute its "load." Thus, the movement of the cochlea fluid originates *at the basilar membrane*. This phenomenon of bone conduction is illustrated quite clearly in my model, which gives localised responses at the same levels whether the tuning-fork is applied to the stapes or to the front or back of the brass case.

There is no reason to suppose that the case is different for air-borne sounds. We can state positively that the waves of sound do produce alternating pressure changes in the cochlea fluid, but we cannot be certain that any movement of the cochlea fluid results from these pressure changes until one or more of the sectors of the basilar membrane is set swinging.

Regarding the action of the cochlea entirely as a resonance manifestation, fluid friction counts only as a damping factor. It has important bearing on sharpness of resonance and persistence of vibration, but its magnitude is very difficult to estimate.

I am afraid I do not quite follow Prof. Roaf's suggestion as to the spiral ligament. He says "the greater bulk of the spiral ligament [in the basal coil] may be merely to resist a greater strain." Does he mean bending strain or breaking strain? If the former, the only way in which it could so act would be by producing increased tension, as I (following Gray) have supposed. If the latter, the breaking strain of the basilar membrane would be determined by the strength of its weakest part. However strong the spiral ligament might be, it could not prevent the basilar membrane being torn if excessive force were applied to it. GEORGE WILKINSON.

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Breeding Experiments on the Inheritance of Acquired Characters.[1]

By Dr. PAUL KAMMERER, University of Vienna.

ALMOST a quarter of a century has passed since I commenced to examine the inheritance of certain breeding- and colour-adaptations which I had obtained with amphibia and reptiles. I did not expect, in relatively so short a time, to obtain positive results, and, moreover, I was then well under the spell of Weismannism and Mendelism, which both agree that somatic characters are not inherited.

In the year 1909 I succeeded in ascertaining that *Salamandra atra* and *Salamandra maculosa* can be so bred as to produce a complete and hereditary interchange (of reproductive characters). The fact that *Salamandra atra*, which propagates itself in a highly differentiated manner, can be made to propagate itself in the manner of *Salamandra maculosa* need not necessarily be regarded as the acquisition of a new character, but may be an atavism. Since, however, the breeding habits of *Salamandra maculosa* can be changed to those of *Salamandra atra*, this objection is (in this case) excluded. I have hitherto always believed that no true inheritance underlay this phenomenon, but only the appearance of heredity (*Scheinvererbung*)—the external conditions applied (such as moisture) affect the germ plasm in the direct physical and not primarily physiological manner.

In view of my researches on the change of colour in *Salamandra maculosa* I could no longer entertain this belief. If the young animals are kept on a black background they lose much of their yellow marking and, after some years, appear mainly black. The offspring of these, if kept again in black surroundings, bear a row of small spots, chiefly in the middle line of the back. If the offspring, however, unlike their parents, are reared on a yellow background, these spots fuse to a band.

The yellow markings of the parent generation reared in yellow surroundings increase at the expense of the black colour of the Salamandra. If now the descendants of such strongly yellow individuals be kept on a yellow background, the yellow portions grow and appear as wide bilateral stripes. Descendants, however, which, unlike their parents, are now kept on a black background have less yellow, but proportionately far more than the background produces in the offspring of parents raised in black surroundings. The yellow markings are arranged symmetrically in rows of spots on both sides of the body.

It could now be said that the diminution of that colour which in the parents has become increased exhibited the nature of a non-inheritance. The acquired colour does not remain constant but diminishes. Ultimately, the grandchildren would have regained the same colour distribution as that of the initial parents. Therefore it could be argued we have merely an *after-effect* and *not* inheritance.

Against this view, however, we have to consider several points. (1) Young Salamandra kept on a black background, and reared from parents which had not been kept in yellow surroundings, become blacker in a much shorter time than those (on a black background) which had been reared from parents kept in yellow surroundings. (2) The descendants in my experiments are not merely placed in intermediate conditions (for example, a mixture of yellow and black backgrounds), as was done in most other breeding experiments on the inheritance of acquired characters—for example, those of Standfuss and Fischer on butterflies and of Sumner on mice. But the descendants are placed in opposite conditions: strongly yellow Salamandra are placed on a black background, and *vice versa*. Each tendency must be neutralised by the opposing stimulus; it cannot be thought that living matter behaves in this respect differently from non-living matter. (3) The yellow colour of the Salamandra, which descends from parents which have become very yellow, has at first a tendency to increase in spite of the opposing effect of black surroundings. The rows of spots of the freshly metamorphosed animals tend to fuse into stripes, just as in the case of animals brought up on a yellow background. Only later these stripes break up into spots again.

Curt Herbst, in 1919, reproached me by saying that I did not mention the augmentation of yellow pigment on a black background, and *vice versa*. It can be seen from my slides, which I have already shown in 1909 to the Congress of German Naturalists in Salzburg, and in 1910 to the International Zoological Congress in Graz, that I have made this augmentation clear. I have always emphasised this phenomenon of inheritance, which Herbst did not recognise as such.

Finally, we must not neglect how I have selected my material. For the experiments on a black background I used Salamandra which were richly marked with yellow; for those on a yellow background, Salamandra which were least marked with yellow. I used, therefore, a negative—or contra—selection to exclude the objection that I was using animals specially suitable for the colour changes which they had to undergo. I had, indeed, to contend with the fact that my animals were specially unsuitable for the experiments. Those which would have to change their colour to black were apparently burdened with a tendency to yellow, while the others which would have to produce a yellow race would have to contend against an opposing inheritance influence.

In the Vienna woods, where I had myself collected my experimental material, there were only asymmetrically spotted Salamandra (*forma typica*). My breeding experiments had changed the spotted Salamandra into the striped form. The striped race (*forma taeniata*) occurs also in the open; it is true, not in Vienna, but in districts where the earth is coloured yellow or yellowish red. In the experiments which I am about to describe I used Salamandra from the Harz Mountains, and it was found that the young of these (as in the experiment) immediately after metamorphosis already possessed their *taeniata* markings. In another case, that of Salamandra originating from the surroundings of Heidelberg, the freshly metamorphosed young were irregularly spotted, as in *forma typica*, and only arranged their markings during their growth into *taeniata*. Curt Herbst has noticed this ontogenetic recapitulation,

[1] Lecture delivered before the Cambridge Natural History Society on April 30.

and has therefore unwittingly confirmed my breeding experiments. The development of *typica* into *taeniata* is reversible, for it also happens that *forma taeniata* will change back to *forma typica*. Mr. E. G. Boulenger has confirmed this in experimental animals which he kept in the larval condition on colour backgrounds. He obtained in this way results far more beautiful and significant than my own.

At the end of the experiments, then, I have two types of striped Salamandra: first, the Salamandra which are found in Nature; and, secondly, those which have been bred in the laboratory from spotted parents. The former is an anciently established natural race, the latter a "new" laboratory race, and both of these are externally identical. I used both types for intercrossing and inter-transplantation and also to complete my transmutation experiments.

If spotted Salamandra be crossed with naturally striped Salamandra, the offspring are of either one race character or the other in the Mendelian fashion. Spottedness is dominant over stripedness. If one crosses naturally spotted Salamandra with experimentally striped Salamandra the hybrids are of an intermediate character (stripe-spottedness) and Mendelian segregation does not occur. The hybrid indicates therefore a difference between "old" and "new" characters, even though it happens that externally both are identical. Doubtless both are heritable, but only the long-established race characteristic obeys the Mendelian laws. The new characteristic does not exhibit any atavistic tendency toward the grandparent race. These facts acquire a special interest when we recall that the vast majority of Mendelian experiments has been done on long-established race characters.

These old and new characteristics can be distinguished, not only by means of crossing-experiments, but also by means of experiments on ovarian transplantation. If ovaries of spotted females are transplanted into the naturally striped ones, then the appearance of the young is determined by the origin of the ovaries—according to the *true* mother and not according to the foster-mother. They are always irregularly spotted. If, on the other hand, ovaries of spotted females are transplanted into artificially striped ones, then, if the father is spotted, the young are line-spotted; if the father is striped, the young are wholly striped.

The ovary of the spotted female brings into the body of the naturally striped foster-mother only its own hereditary properties as effective in fertilisation. In the body of an artificially striped foster-mother this same ovary behaves as if it had been derived from the body of a striped female and as if the eggs of the striped female had been used in the crossings.

The objection cannot be raised that the operation was not thorough—that portions of the original ovaries may have been left behind in the foster-mother, as in Guthrie's experiments on fowls, which were afterwards tested by Davenport and found to be merely cases of regeneration of the original ovaries. Thanks to its enclosing membrane, the ovary of the Salamandra can be removed from the surrounding tissue as a whole. It is impossible that any remnants could have been left behind and that the descendants were derived from these remnants regenerated.

These experiments on ovarian transplantation first led me to consider the possibility of the true inheritance of somatic characters. This conception of mine was supported by the experiments of Secerov, who, to begin with, had obtained analogous changes in *Salamandra maculosa* (*forma taeniata*) by influencing the larvæ. Secondly, Secerov had measured the amount of light which was able to penetrate the interior of the body of the Salamandra. Only one-sixth of one per cent. of the outer light reached the ovaries, and the colours of the surroundings were reduced by absorption by the skin. It is improbable, therefore, that there could have been any direct colour influence on the cells of the ovary and a colour-adaptation by "parallel induction." After considering this, together with the results of transplantation, only one plausible hypothesis remains, namely, that the colour changes become inherited by a "somatic induction"; by a process similar to, if by no means the same as, that which Charles Darwin had already imagined in his theory of Pangenesis and Cunningham and Hatschek brought forward later on to explain the phenomena of heredity.

The different reactions of old and new, inherited and acquired, characters in transplantation and crossing, I have tried to make intelligible by an analogy, I must confess, provisional and crude. A new piece of clothing irritates, but this irritation diminishes the longer the clothing is worn, and it ultimately disappears. Likewise, there is a morphological irritation from each part of the body, and this diminishes in the same way. When there have been recent changes the irritation is stronger. Under suitable conditions of duration and intensity the irritation penetrates to the germ plasma. There it renders permanent a potentiality for repetition of the actual change which brought it into play. In a new character, as time goes on, the morphological irritation diminishes. Its germ-plasmic induction is no longer effective. It now belongs to the past. For the present it is no longer necessary, because without it the corresponding tendency is fixed in the germ cells. The *inductive dependence* is a relation existing between the germ plasm and only newly acquired characters. Between germ plasm and old characters, the morphological irritation of which has by use long since disappeared, there exists a complete independence as demanded by Weismann's theory and proved by Mendel's experiments.

I will now touch briefly on further results of my experiments, though these now deal not with inheritance but with changes induced on one generation. Since it is just these experiments which are cited as evidence against the inheritance of acquired characters, it will not be out of place to give a brief refutation of this, as I think, mistaken interpretation. I have succeeded in developing the rudimentary visual organ of Proteus unto a full-sized functioning eye by red illumination to which the animals were exposed for five years from birth. The degeneration of the eyes in cave-dwelling animals, according to the other view, cannot be made hereditary. It is only a non-hereditary modification, a mere environmental change. Otherwise it would be impossible, by exposure to light for a single generation, to undo what life in darkness for so many generations had produced.

What contradicts this view is that exposure to ordinary daylight is not effective. In daylight the skin which covers the rudimentary eye is filled with a dark pigment. This considerable but by no means complete absorption of light due to the pigment is sufficient to arrest the development of the eye, so that the normal degeneration occurs. Red light, however, causes no pigmentation in the skin, and only under the influence of this chemically inactive light is the regression overcome.

The misinterpretation of these data allows me to make a further general observation. In order to prove completely that acquired characters are inherited we must produce at least one alteration of an inborn property. But if we only recognise those properties as hereditary which are unchangeable, then we have *from the very outset* excluded all heritable transformations, and at the same time rendered useless any investigations of the matter. If that which changes cannot be hereditary, and if that which is hereditary cannot change, we can only predict the immutability of species and therewith dogmatically leave on one side, not only the inheritance of acquired characters, but also the whole theory of evolution.

All existing objections, which rendered insoluble the inheritance of acquired characters, apply also to my breeding experiments on Alytes, and I myself would not have attached any special significance to this were it not that it is a result of just these experiments which has aroused the keenest interest in England—the development of a nuptial pad in the male Alytes. In male frogs, which pass their mating-time in water, there appears before mating, usually on the inner fingers, a rough, horny, glandular, dark-coloured pad. On the other hand, in Alytes, which mate on land, no trace of such a pad is to be seen. Yet it can be made to appear after several generations by compelling the Alytes to mate in water, like other European frogs and toads. This compulsion is brought about by raising the temperature, under which condition the mating animals stay longer in the water than usual, for if they did not do so they would run the risk of being dried up. Later in life compulsion becomes unnecessary. The stimulus of warmth produces an association through which henceforward the Alytes take to the water of their own accord when they wish to mate.

Of the many changes which gradually appear in this water breed during the various stages of development—egg, larva, and the metamorphosed animal, young and old—I will describe only one, the above-mentioned nuptial pad of the male. At first it is confined to the innermost fingers, but in subsequent breeding seasons it extends to the other fingers, to the balls of the thumb, even to the underside of the lower arm. After spreading, it exhibits an unexpected variability, both in the same individual and between one individual and another. The variability in the same individual is shown by the characters altering from year to year and in the absence of symmetry between the right hand and the left. In one specimen the dark pad extended to all the other fingers and almost over the whole of the left hand. On the right hand it was never so marked, and it was even less developed later, because the skin was stripped from this hand in the living animal for the purpose of histological investigation. The present skin and pad formation next to the inner finger is to be ascribed to regeneration in the mating season which followed. Microscopical preparations show the difference between the thumb skins of the mating male Alytes in the control breed and the padded skins of the water breed. The skin on the thumb of the normal male is subject likewise to an annual change in thickness. Alytes has already in its natural state a tendency to pad formation, and therefore does not display such a striking novelty as microscopic observation would lead one to think.

The great variability and extent of the pad, which can be produced by cultivation, and its independence of the testes, as castration experiments show, render the hypothesis possible, that what we are dealing with is an artificial creation of a new function. On the other hand, the Alytes pad can be interpreted as an atavism; or again, since the tendency was already there, one can quite well deny that the character has been acquired. Further, the influence of the heat responsible for the change penetrates the whole body of the cold-blooded animal and may therefore penetrate to the germ plasm in a purely physical manner. It is true that when four generations have altered in a similar manner, even after the stimulus has been removed, it is not very plausible that parallel induction should be the cause, and the subsequent appearances a mere after-effect. But as the atavism objection can always be raised, it is not very clear to me why just this experiment (with Alytes) is so often looked upon as an *experimentum crucis*. In my opinion it is by no means a conclusive proof of the inheritance of acquired characters.

Not content with any of the previous experiments, I carried out, before 1914, what may really be an *experimentum crucis*. I have written a few words on it in my "Allgemeine Biologie." There has been no detailed publication as yet. The subject is the Ascidian, *Ciona intestinalis*. If one cuts off the two siphons (inhalent and exhalent tubes), they grow again and become somewhat larger than they were previously. Repeated amputations on each individual specimen give finally very long tubes in which the successive new growths produce a jointed appearance of the siphons. The offspring of these individuals have also siphons longer than usual, but the jointed appearance has now been smoothed out. When nodes are to be observed, they are due not to the operation but to interruptions in the period of growth, just as in the winter formation of rings in trees. That is to say, the particular character of the regeneration is not transferred to the progeny, but a locally increased intensity of growth is transferred. In unretouched photographs of two young Ciona attached by their stolons to the scratched glass of an aquarium, the upper specimen is clearly seen to be contracted; the lower is at rest and shows its monstrously long siphons in full extension. They were already there at birth, for it was bred from parents the siphons of which had become elongated by repeated amputation and growth.

In those animals with artificially lengthened siphons we can, furthermore, combine with the amputation at the front end another amputation at the hinder end. At the hinder end—in the coils of the intestine

—lies the generative organ, an hermaphrodite gland. We remove the whole of this part of the body and leave the front part to regenerate and to reproduce a new generative organ; that is, *new germ plasm is formed from somatic tissue.* It has been established already in several species of animals and plants that Weismann's "continuity of germ plasm" is not obligatory but, at most, a facultative continuity. The long-siphon Ascidians with regenerated germ plasm give birth to progeny also long-siphoned. In this way the most familiar objection brought against the inheritance of acquired characters—the claim that there is a direct influence on the germ plasm—is, I think, definitely removed. The local character of the operation in cutting off the siphons renders this chief objection almost inapplicable. We might, however, still argue that physical influence still obtains; that while I am cutting the siphons at the head, a direct physical reaction is taking place on the germ plasm. In this case there would already be established that tendency which would give rise to an apparent inheritance in the progeny.

But now we cut away all the generative organ, with all its germ cells and its active and latent tendencies. We await the growth of a new generative organ. The regeneration takes place at a time when there are no further disturbances influencing the body. Nevertheless, the growth to which it gives rise is still affected. The change therefore cannot have been lying preformed in the original germ plasm. It can have come ultimately from nowhere but from the changed body.

The present circumstances are scarcely favourable for the furtherance of these researches in heredity in my impoverished country. During the War experimental animals, the pedigrees of which were known and had been followed for the previous fifteen years, were lost. I am no longer young enough to repeat for another fifteen years or more the experiments, with the results of which I have been long familiar, before I attempt to break new ground. The necessities of life have almost compelled me to abandon all hope of pursuing ever again my proper work—the work of experimental research. I hope and wish with all my heart that this hospitable land may offer opportunity to many workers to test what has already been achieved and to bring to a satisfactory conclusion what has been begun.

The Earth's Electric and Magnetic Fields.[1]

By Prof. W. F. G. SWANN, University of Minnesota.

I.

QUITE apart from those more spectacular manifestations of atmospheric electric phenomena associated with the thunderstorm, we have to recognise the following facts, as pertaining to the ordinary quiet day:

(1) The earth is charged negatively to such an extent as to give rise to a vertical potential gradient which amounts to about 150 volts per metre at the surface of the earth, and goes through fairly regular variations throughout the day and throughout the year, variations amounting to 50 per cent. or more of its total value.

(2) The potential gradient diminishes with altitude until its value at 10 kilometres is practically negligible compared with that at the earth's surface, a result which is brought about by the existence, in the atmosphere, of a positive charge, the total amount of which below the altitude 10 kilometres is practically equal to the negative charge on the earth's surface.

(3) The atmosphere is a conductor of electricity. The conductivity near the earth's surface is so small that a column of the air one inch long offers as much resistance to the flow of the electric current as would a copper cable of equal cross section extending to the star Arcturus and back twenty times over.

(4) In spite of the smallness of the conductivity of the atmosphere at the earth's surface, its amount is nevertheless sufficient to ensure that 90 per cent. of the earth's charge would disappear in ten minutes if there were no means of replenishing the loss.

(5) The conductivity increases with altitude at such a rate that its value at an altitude of 10 kilometres is about fifty times that at the earth's surface, and there is indirect evidence to substantiate the belief that at altitudes of the order of 100 kilometres it may attain a value more than 10^{11} times that at the earth's surface. Such a conductivity would cause the upper atmosphere to act, practically, as a perfect conductor in its relation to phenomena in the lower atmosphere.

(6) There is some evidence for and some against the view that our atmosphere is traversed by a radiation of cosmical origin, and of penetrating power ten times, or more, that of the gamma rays of radium.

A potent factor contributing to the conductivity of the atmosphere is the radioactive material in the air and soil. There are, on the average, about 1·5 molecules of radium emanation per c.c. of the atmosphere over land, yet this small amount is sufficient to contribute very appreciably to the ionisation there. On the basis of the known amounts of radium and thorium emanations in the atmosphere, and of radioactive materials in the soil, we could account fairly well for the ionisation of the lower atmosphere. The conductivity of the air over the great oceans is, however, practically as great as it is over land, and is very much greater than can be accounted for by the radioactive materials, which are negligible in amount in the ocean and in the air over it. The assumption of a penetrating radiation would provide a cause for the ionisation known to exist over the sea. If, however, we are unwilling to admit the existence of such a radiation, the ionisation over the ocean remains to some extent a mystery, and may have to be attributed to a small spontaneous ionisation of the gas.

The great problem of atmospheric electricity is, of course, the explanation of the maintenance of the earth's charge. The replenishment to be accounted for is small, amounting to only 1000 amperes for the

[1] Portions of a lecture on "Unsolved Problems of Cosmical Physics," delivered before the Franklin Institute on December 20, and published in full in the Journal of the Franklin Institute.

whole earth. As regards the positive charge in the atmosphere, there is little difficulty provided that we can account for the maintenance of the negative charge on the earth. For, even though a theory which accounted for the latter did not immediately imply the former, the known fact of the increase of atmospheric conductivity with altitude, combined with the law of continuity of flow of the electric current, would be sufficient to bring the positive charge into evidence. One of the earliest theories of the earth's charge is due to C. T. R. Wilson, who supposed that the atmospheric ions would serve as nuclei for the precipitation of rain, and that the drops would form more readily upon the negative than upon the positive ions, with the result that rain would be, on the whole, negatively charged, and would thus constitute the replenishment of the loss by conduction. The difficulty confronting this theory lies in the fact that the conditions necessary for the precipitation of rain on ions to form drops of appreciable size, do not readily occur in the atmosphere, and in the still more potent fact that, so far as measurements go, 90 per cent. of the rain which falls is positively charged. Thus, while rainfall may constitute a factor in the replenishment of the earth's charge, it is not one which operates in the right direction to serve as the sole cause.

Another theory of replenishment, depending ultimately upon gravity for the separation of the charges in opposition to the electric field, is that due to Ebert. It constitutes a modification of an earlier theory due to Elster and Geitel. Ebert's theory invokes the fact that if an ionised gas be passed through a fine tube the negative ions diffuse to the walls of the tube more rapidly than do the positive ions. Ebert supposes that, during periods of fall in barometric pressure, the air in the pores of the soil, which is ionised on account of the radioactive material therein, becomes drawn out into the atmosphere, positively charged on account of its having deposited an excess of negative ions in the interstices of the soil. Rising currents of air are then invoked to explain the transference of the positive ions to appreciable altitudes, against the electrostatic attraction of the negative. This theory has been criticised on account of the insufficiency of the charging action resulting from the diffusional process, on account of the smallness of the upward convection current of positive electricity as measured experimentally, and on account of the fact that it may be shown to predict a diminution of potential gradient with altitude such as would result in the gradient itself being practically negligible at an altitude of a kilometre.

The precipitation theory, and the Ebert theory, are of a type in which the replenishing action takes place over a limited region of the earth's surface at any one time, in such a manner that the positive electricity which is the counterpart of the negative charge on the earth is to be found in this limited region of the atmosphere. Under such conditions, the negative charge will be held on the portion of the earth's surface which lies in the immediate vicinity of the positive, and the potential gradient will be confined to this region. A partial way out of this difficulty can be found, however, if we admit the existence of a highly conducting layer in the upper regions of our atmosphere. In this case, the charge separation sets up a potential difference between the layer and the earth, so that the potential gradient, which would otherwise be confined to the region of replenishment, is shared as it were by the earth as a whole. Thus, for example, calculation shows that if a charged cloud is to be found at an altitude h above the earth's surface, and if H is the altitude of the conducting layer, and R the radius of the earth, the hemisphere of the earth which is symmetrically remote from the charged cloud receives R/H times the number of tubes of force which it would receive in the absence of the layer, and h/H times the number which it would receive if the negative charge on the earth and the positive charge in the cloud were spread uniformly over the earth and atmosphere respectively. It may be remarked, moreover, that this action of the conducting layer provides a partial loophole for escape from the particular objection to the Ebert theory which is founded on the impossibility of the positive charge reaching an altitude of more than a kilometre or so. Even such a small separation in the region of replenishment would make its own contribution to the potential gradient at other places through the medium of the conducting layer. The contributions in these places would be of a perfectly normal type, the variation with altitude being determined only by the nature of the variation of conductivity with altitude, in such a manner as to keep the vertical conduction current density independent of altitude.

In 1904 G. C. Simpson proposed a tentative theory of the earth's charge, in which it was assumed that the sun emitted negative and positive corpuscles of high penetrating power. The former were supposed to pass right through our atmosphere and penetrate the earth, while the latter were caught in the atmosphere. Such a degree of penetration is very much greater than any we are familiar with in the laboratory, for the beta rays of highest energy investigated will pass through only about 10 metres of air.

We can account for the replenishment of the earth's charge if we suppose that the atmosphere emits high-speed negative corpuscles. The earth will then charge up on account of the corpuscles which come from the molecules of air lying within striking distance of it. Such a possibility was examined by the writer in 1915. So far as the replenishment of the charge is concerned, the average range of the corpuscles may be made as small as we please by supposing a sufficiently copious emission of corpuscles. It turns out, however, that appreciable values of the potential gradient become confined to altitudes comparable with the average range, so that for this reason a large range must be assumed. This difficulty is avoided in a somewhat similar theory suggested by the writer, and somewhat later, but quite independently, by von Schweidler. According to this theory, the emission of corpuscles from the atmosphere is caused by the penetrating radiation which, coming from above, and being of a very hard type, ejects the corpuscles almost completely in a downward direction. If we assume that only three corpuscles are emitted per c.c. per second, by the penetrating radiation, an average range of nine metres in air at atmospheric pressure is sufficient to account for the replenishment of the earth's charge.

Two main difficulties confront any corpuscular theory of the earth's charge. The first arises from the failure to detect any charging effect, as a result of the influx of corpuscles, in the case of a mass of insulated metal surrounded by a thin metal shield to protect it from the potential gradient. The second arises from the fact that, in so far as the replenishment of the earth's charge requires the entry of 1500 corpuscles per sq. cm. per second, and, a corpuscle moving with a velocity approximating that of light produces about 40 ions in each centimetre of its path, we should expect a rate of production of 60,000 ions per c.c. per second. Experiment reveals a rate of production of less than 10 ions per c.c. per second, and these are attributable, for the most part, to known causes.

As regards the former difficulty, experiments to detect the charging effect were made by the writer in 1915, and more recently by von Schweidler, without finding any such effect. Unless we assume corpuscular ranges so great that there is negligible absorption in the test body, this result opposes any theory which invokes corpuscles shot into the earth from regions outside our atmosphere, or from the atmosphere itself as a result of direct spontaneous disintegration. The experiment is not so much in conflict with theory in the case where the corpuscles are emitted by the penetrating radiation, however. If the penetrating radiation is sufficiently hard to pass through the test body without appreciable absorption, it can be shown that it will eject as many corpuscles from the lower side of the body as it injects on the upper side.

Serious as the difficulty concerned with the ionising action of the corpuscles seems at first sight, there is a natural way of avoiding it, providing that we assume the corpuscles to have velocities so closely approximating the velocity of light that their tubes of force become crowded very greatly towards the equatorial plane. In these circumstances, if a corpuscle [2] is to give even a small finite amount of energy to an electron in the process of ejecting it from an atom, it must give it in an infinitesimal time, and such a phenomenon would require the payment of an infinite tax in the form of energy radiated. A full consideration of the details of the action shows that the reaction on the electron, due to its radiation, is such that, for any ionisation potential of the atom, there is a velocity sufficiently near to that of light, such that a corpuscle having that velocity would be unable to produce any ionisation in the gas.

The ionisation potential of oxygen, which is less than that of nitrogen, is 15·5 volts, and on the classical theory of electrodynamics a corpuscle would fail to ionise oxygen or nitrogen for all velocities in excess of 200 metres per second below the velocity of light. It may be of interest to remark that, in order that an electron should strike down into our atmosphere in the vicinity of the equator and reach the earth's surface, without being bent back by the earth's magnetic field, it would have to possess a velocity nearer to that of light than the above value, so that the very fact that it could reach the earth would be sufficient to ensure that it would not ionise on the way. Moreover, as another illustration of the same principle, it may be remarked that the above value for the velocity lies between the two limits, 400 metres per second less than that of light, and 4 metres per second less than that of light, assigned by Birkeland as the limits between which the velocities of negative electrons from the sun must lie in order that they shall be capable of accounting for the aurora. Of course, failure to ionise would prevent corpuscles from functioning as regards the aurora, and the figures in question are only cited for their general interest. There are other reasons for believing that the aurora is not caused by negative electrons.

Once we assume these high energies for the corpuscles, they carry with them the possibility of very great penetration, as may be shown from a consideration of the circumstances which determine absorption in the atmosphere. This penetrating power is enhanced by the diminution of the power of the corpuscles to communicate energy to the electrons by which they pass. Thus, while, as regards the mere explanation of the earth's charge, we may avoid the assumption of long ranges, as in the theory which invokes the penetrating radiation to eject the corpuscles from the air, we find it necessary to postulate, for the corpuscles, velocities closely approximating the velocity of light, in order to explain the absence of ionisation, and this of itself implies long range as a consequence.

(*To be continued.*)

[2] The word "corpuscle" is merely used to distinguish the high-speed electron, the ionising powers of which are under discussion, from the electron in the atom.

The Royal Academy, 1923.

THE private view of this year's Exhibition of the Royal Academy took place on Friday, May 4. The juxtaposition of the Royal Society and the Royal Academy suggests something deeper than the accident of both being dependent upon the patronage of the wealthy and the hospitality of the State. On either side of the wall that separates the academies of art and science the work is alike also in this—the impulse of the worker is to represent and thereby to preserve the visions that he has seen, that others might have seen if they had been gifted with the insight that sees things hidden from the rest of the world by the blinding candour of Nature. One uses paint or clay, and the other the printing-press or the experimental table; and however dependent either may be on the smile of the wealthy or the favour of the potentate for the means to "carry on," the satisfaction of achievement in the effort to express what they alone have seen with the mind's eye redresses for either the adverse balance of many an account. A year's Proceedings of the Royal Society show what the fellows wish to hand on to posterity as expressing their searching into Nature: so the yearly exhibition at Burlington House represents the messages to which the artists of to-day have dedicated their power of insight.

Passing through the galleries for the first time one wonders what message the artist is trying to convey and whether he has succeeded. There can be little doubt that 200 (*Still Life*, by Meredith Frampton) aspired to give the impression of china ducks and flowers, and has succeeded; and the same may be said of an impressive study of huge Atlantic waves close at hand, with a tiny ship in the background, 558 (*Henry Hudson, 1607*, by Norman Wilkinson); but what the message is in 15 (*Little Dancer*, by Glyn Philpot) is less obvious: it is perhaps the beauty of gradations of subdued colour. So also the piece by the same artist, 170 (*Penelope*), and 34 (*Youth*, by F. Cayley Robinson), and in a drab monotonous way 155 (*Hayling Island*, by Oliver Hall). There are others, on the contrary, who use vigorous contrasts instead of gentle gradations. Such are 36 (*Rocks, Tregiffran*, by Robert M. Hughes), 53 (*Sennen Beach*, by Laura Knight), and 234 (*Wiltshire Downs*, by Edward Buttar), and even more impressive as an appeal to the sense of beauty of colour, saffron with blue shadows and pink sky, 151 (*An Autumn Evening in the Western Highlands*, by Adrian Stokes), and 264 (*Seagulls Nesting*, by Charles Simpson), a vision of the colours of spring. Not always satisfying are these schemes; 366 (*Sons of the Sea: Polperro, Cornwall*, by John R. Reid) makes one think of the artist's colourman rather than Nature's beauty.

One of the striking features of the pictures by the well-known artists is the sensation of vivid illumination. Marked discontinuities of light and shade give the effect, obviously desired, in 25 (*Ariñez on the Battlefield of Vitoria, Spain*, by James P. Beadle), 72 (*Glebe Place, Chelsea, 1922*, by George Henry), 175 (*Lovers of the Sun*, by H. S. Tuke), 278 (*Market Jew: Thursday*, by Stanhope A. Forbes), and 174 (*An Italian Lemon Garden*, by H. H. La Thangue): in the last the discontinuities are perhaps too strong for real pleasure. There is a wonderful sense of luminosity from discontinuity of colour alone without very marked shadows in another picture by the same artist, *The Mill Stream* (64), and also in 336 (*The Finish*, by Harry Fidler).

A juxtaposition of colours that one may call iridescence is artfully used to convey the sensation of local luminosity in 126 (*Golden Summer, Cornish Coast*, by Julius Olsson), and 191 (*Surf-bound Shore*, by the same artist), and 565 (*The Coastwise Lights*, by Harry Van der Weyden); also, but less successfully, for the illumination of the misty atmosphere of a setting sun of vast dimensions in 379 (*The Fading Day*, by Fred Hall). Some artists boldly paint a parti-coloured background and let the spectator regard it as sky if he please. That is noticeable in the colour scheme of 19 (*The Trojan Women*, by Charles Ricketts), in 226 (*The Sons of Ellis Hajim, Esq.*, by Charles Sims), and 229 (*Brood Mares and Foals at Southcourt Stud*, by Alfred J. Munnings).

As a fellow-student of Nature one cannot but feel that the sky must be a very exasperating part of an artist's subject unless it is all blue, or all grey, or all pink. When there are clouds with definite shape and movement the representation of Nature's varying mood is very difficult. The natural sky, even when it is most complex, is not chaotic; it has lines and touches that suggest order, a horizontal alignment, a characteristic shape, the detail of an outline, but so subtle and so transient that, while the student is meditating its features, they are gone. Apparently only the more noted artists challenge the heavens with a presentation of this subtle order in disorder, and not with complete success. 137 (*Tilty Church*, by George Clausen) shows clouds of easily recognised shape, but lacking the characteristic detail of outline. The most successful skies succeed by evading the real problem. The beautiful picture of *The Port of London* (213), looked at from above, by W. L. Wyllie, makes an atmosphere of native smoke and excuses the sky. Almost the same artifice is used in another picture by the same artist, *A Storm is Coming* (217). Details are also avoided by a general "all-overishness" in 162 (*The Lowlands of Holland*), 310 (*In from the Sea*), both by Robert W. Allan, and 370 (*A Grey Sea*, by the Hon. Duff Tollemache), and in a beautiful Scottish snow picture (124) by Joseph Farquharson. The challenge is evaded in 236 (*Summer Morning, St. Ives*, by Charlton Fortune) by filling up the sky with seagulls; but it is deliberately taken up by Arnesby Brown in quite a number of pictures—3 (*September*), 79 (*The Swing Bridge*), 130 (*The Waiting Harvest*), 148 (*The Watch Tower*): the disorder is there patent, but the whisperings of order in a disordered sky are missing. No more successful in this respect are 178 (*A May Morning at Southcourt*, by A. J. Munnings), 203 (*The Mountain Stream*, by Lewis T. Gibb), 335 (*Dover and Castle from the North*, by Frank P. Freyburg).

There is a peculiarity about natural skies; without any effort one is conscious that one is watching either the plan of an extensive layer or the elevation or profile of individual clouds. It is only occasionally that one gets that sort of satisfaction out of a picture. It is very nearly complete in 207 ("*If the clouds be full of rain, they empty themselves upon the earth*," by Frank Walton), in a picture by R. Vicat Cole, and in 484 (*Tintagel*, by Algernon Talmage). One misses it in 199 (*The Blue Pool*, by the late Mark Fisher), and in 259 (*Before the Ruined Abbey*, by Sydney Lee). It has often been remarked that the Greeks and Romans had no names for the forms of clouds which we have learned to recognise so easily. The exhibition suggests that the reason lies very deeply set.

As one leaves the galleries the questions as to what message the artists meant to convey and whether they have succeeded recur. Among the pictures most satisfying in answering both questions at first sight we may name 47 (*The White Sands of Scilly*, by Julius Olsson), 124 ("*Some gleams of sunshine mid renewing storms*," by Joseph Farquharson), already mentioned, 333 (*Green-clad Hills, Lake of Annecy*, by Terrick Williams), and 636 (*Winter Evening, Engelthal*, by Adrian P. Allinson).

Judging from experience outside, one might have been afraid that the Academy of 1923 with its multitude of portraits would have been a nightmare of horn-rimmed spectacles: it is not so. There is only one specimen, *Portrait of the Painter*, by the late Sir J. J. Shannon. The pervading influence of the War has also passed away except in the sculpture rooms and in the satiric picture by Sir William Orpen.

Scientific worthies are not very conspicuous in the collection. There is a bronze bust of the late Dr. Ludwig Mond, and one of the late Sir James Dewar (by G. D. Macdougald); also a marble bust of Sir J. J. Thomson, by F. Derwent Wood, as well as the portrait by Fiddes Watt.

Current Topics and Events.

THE growth of our knowledge of stellar physics during the present century has been surprisingly rapid. It has arisen by combining the results of researches of most varied kinds. The older astronomy of position has afforded the data for the positions, distances, and motions of the stars, which were a preliminary to the establishment of the theory of giant and dwarf stars, and also to the detection of the possibility of finding parallaxes by the spectroscope, and so distinguishing the giants from the dwarfs. In another field, the discovery of radium, and radio-activity generally, has revolutionised ideas on the nature of the atom, and led to the detection of analogies between chemistry and dynamics. Prof. Eddington, whose lecture on "The Interior of a Star," delivered at the Royal Institution on February 23, is printed as a supplement to the present issue, is one of the leading pioneers in this field. His earliest astronomical work was concerned with stellar distances and proper motions; but he has recently worked more on the physical side. Prof. Eddington was one of the first to point out the importance of light pressure in causing the distension of giant stars, and also to suggest that the immense duration of their output of energy is explicable by their drawing on the store of energy in the atom. This was first offered as a tentative explanation, but Prof. Eddington now makes it definitely. A remarkable confirmation of the correctness of the accepted views on stellar physics was afforded by the close agreement of the diameter of Betelgeuse, as given by the interferometer, with that deduced from the study of the distribution of energy in the spectrum, which led to a value of the temperature and surface brightness.

THE approaching visit to London of Prof. H. A. Lorentz, of the Teyler Institute at Haarlem, and the University of Leyden, is being eagerly awaited by physicists. Prof. Lorentz is the *doyen* of mathematical physicists. In 1880 he developed from electromagnetic theory a connexion between refractive index and density (known by his name), which holds good through great ranges of density, though requiring a small correction for extreme states as recent experiments on carbon dioxide have demonstrated. At the present time, Prof. Lorentz is acclaimed in the main for the fundamental work he has done in connexion with the electromagnetics of moving bodies. In this work he has served as an intermediary between the old electromagnetics and the modern doctrine of relativity. Einstein's results agree mainly (though not exactly) with those which Prof. Lorentz had obtained, "the chief difference being that Einstein simply postulates what I have deduced with some difficulty and not altogether satisfactorily from the fundamental equations of the electromagnetic field" (Lorentz). Prof. Lorentz contributed to the explanation of the magneto optic phenomena discovered by Zeeman and others. "I may refer in the first place to the intensely stimulating influence of H. A. Lorentz's theories. It is difficult to find adequate words to express my indebtedness to Lorentz's personal inspiration and to his theories" (Zeeman). Prof. Lorentz visited the British Association at the Birmingham meeting in 1913, and made important and guarded contributions to the discussion on radiation and the quantum theory. His first lecture in London is at 5.30 P.M. on May 17, at University College, Gower Street. Admission is free, without ticket. Three other lectures by Prof. Lorentz, at the same place, have been arranged to be delivered in the early part of June. He is also lecturing at Cambridge (Reid Lecture), at Manchester, and elsewhere.

SHORTLY after the death of Dr. W. H. R. Rivers in June last, it was suggested that the eminence of his services to science should be recognised by some form of memorial; but it was not found possible to take any further steps at the time. A few of Dr. Rivers's friends have now formed a small committee with the view of giving the proposal practical effect. Among those serving are: Sir Charles Sherrington, Sir William Ridgeway, Sir Humphry Rolleston, Sir James Frazer, Dr. Henry Head, Dr. A. C. Haddon, Mr. Henry Balfour, Prof. G. Elliot Smith, Dr. C. S. Myers, and Prof. C. G. Seligman. This committee has now issued an appeal for subscriptions to a fund of which Dr. L. E. Shore of St. John's College, Cambridge, acts as treasurer. The fund will be devoted to the promotion of those sciences in which Dr. Rivers was particularly interested, but the decision as to the manner in which this will be effected will rest with the subscribers, of whom a meeting will be summoned in due course. It is permissible to express a hope that the committee and subscribers will decide to devote the fund to some object which it is known that Dr. Rivers had closely at heart, such as, for example, the assistance of the publication of scientific memoirs for which ordinary scientific or commercial channels are not available on the ground of cost.

DURING the summer of 1922 a member of the Cambridge Natural History Society was in Vienna and made the acquaintance of Dr. Kammerer, who appeared to be willing to visit England, should an opportunity occur. After further correspondence with Dr. Kammerer, the matter was placed before the council of the society in March last, and it was then decided that Dr. Kammerer should be invited in the name of the society to give a lecture at Cambridge. The invitation was accepted by Dr. Kammerer, and the lecture is published elsewhere in this issue. All expenses of the journey were provided for by contributions from members of the society, and on April 25 Dr. Kammerer arrived in England, and has since been the guest of the society.

THE Croonian lecture of the Royal Society will be delivered on June 21 by Dr. F. F. Blackman, who will take as the title of his lecture "Plant Respiration as a Catalytic Process."

DR. JOHN PALIBIN, director of the Botanical Garden at Batoum, has accepted the post of assistant to the museum director in the principal botanical garden of Petrograd, where he hopes to have more opportunity for those researches in palæobotany in which he has won distinction.

AT University College, London, on Friday, May 11, the chairman of the College Committee (the Rt. Hon. the Viscount Chelmsford) is to unveil a tablet commemorating the munificent gifts for the new chemistry building made by Sir Ralph Forster, Bt.

A LOAN collection of pictures painted by Miss Edith Cheesman in Mesopotamia will be on view in the North Gallery of the Imperial Institute from May 7 from 10 A.M. to 5 P.M. daily, except Sundays. Admission is free. The pictures, which are in oils and water-colours, are illustrative of life and scenery in Mesopotamia and include both portraits and landscapes.

A MASTER is required for service on the Colonial Government ship *Discovery*, whose duties will be mainly research in whaling in the Antarctic. Full information and forms of application are obtainable, by letter, from the Secretary, *Discovery* Committee, Colonial Office, S.W.1. No special form is necessary for candidates abroad. The latest day for the receipt of applications is May 31.

THE Air Ministry announces that the Royal Air Force pageant, which was instituted in 1920, will take place on Saturday, June 30, at the London Aerodrome, Hendon, by arrangement with the Grahame White Company. It is hoped that the King will be present. The pageant now affords the general public an annual opportunity of observing developments both on the flying and technical sides of the work of the Royal Air Force.

THE Faraday Society will hold a general discussion on "The Physical Chemistry of the Photographic Process" on Monday, May 28, in the Hall of the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Prof. W. D. Bancroft, of Cornell University, will open the proceedings at 3 P.M. with an introductory address on "The Theory of Photography." This will be followed by detailed consideration of the subject, subdivided as follows:—(1) "The Physical Chemistry of the Vehicle and of the Emulsion"; (2) "Reactions in the Plate during Exposure"; (3) "Development and Characteristics of the Developed Plate"; (4) "Adsorption Reactions in Photographic Films." Each section will be introduced by a preliminary address and followed by general discussion. Among those who will read papers are Dr. T. Slater Price, Dr. F. C. Toy, Mr. Olaf Bloch, Mr. T. Thorne Baker, M. Clerc, Prof. Luther, and Prof. Goldberg. Several communications will be made from Mr. S. E. Sheppard and other members of the staff of the Eastman Kodak Company, and papers are also expected from Dr. Chr. Winther, Dr. Lüppo-Cramer, and Prof. L. Plotnikov. Between the afternoon and evening sessions a complimentary dinner will be given at the Hotel Cecil to Prof. Bancroft and the other guests. Members of the Chemical Society are invited to attend this meeting. Full particulars may be obtained from the Secretary of the Faraday Society, 10 Essex Street, London, W.C.2.

THE New York correspondent of the *Times* states that Lieuts. Macready and Kelly completed a non-stop aeroplane flight across the United States from New York to San Diego on May 3. The distance traversed was approximately 2600 miles and the time is given as 26 hours 50 minutes 38⅖ seconds.

M. GEORGES BARBOT crossed and recrossed the English Channel on May 6 in a small monoplane fitted with a two-cylinder 15 h.p. engine, thus winning a prize of 25,000 francs offered by *Le Matin* for the complete journey. M. Barbot left the aerodrome at St. Inglevert at 6.20 P.M. and arrived at Lympne at 7.21 P.M.; the return journey was commenced at 8.1 P.M., and the aeroplane arrived over St. Inglevert aerodrome at 8.45 P.M.

WE learn from *La Geographie* for February that a wireless station has been erected at Mygbugten, on the east coast of Greenland, in lat. 73° 30′ N., and has been functioning since last October. The station is due to the enterprise of the Norwegian Meteorological Service. Weather reports are sent by wireless telegraphy to the station on Jan Mayen, and thence to Christiania. The Greenland station and those on Jan Mayen, Iceland, Bear Island, and Spitsbergen almost encircle the Greenland sea.

AT the Hull meeting of the British Association in September last there was a discussion in the Section of Anthropology upon the genuineness of some bone implements known as the "Holderness Harpoons" (see NATURE, October 7, p. 481, and December 2, p. 735). Mr. O. J. R. Howarth, secretary of the Association, writes to say that though several references have recently appeared to a committee of the British Association as having pronounced upon the question, no committee was appointed by the Association or its anthropological section to investigate this subject.

AT the annual general meeting of the Manchester Literary and Philosophical Society held on April 24, the following officers and members of council were elected: *President*, Prof. H. B. Dixon; *Vice-Presidents*, Mr. T. A. Coward, Prof. A. Lapworth, Mr. C. E. Stromeyer, and Prof. F. E. Weiss; *Secretaries*, Dr. H. F. Coward and Prof. T. H. Pear; *Treasurer*, Mr. R. H. Clayton; *Librarians*, Mr. C. L. Barnes and Dr. W. Robinson; *Curator*, Mr. W. W. Haldane Gee; *Other Members of the Council*, Prof. W. L. Bragg, Prof. S. Chapman, Rev. A. L. Cortie, S.J., Prof. S. J. Hickson, Mr. F. Jones, Laura Start, Mr. R. L. Taylor, Mr. W. Thomson, and Mr. L. E. Vlies.

THE council of the Institution of Civil Engineers has made the following awards in respect of papers read and discussed at the ordinary meetings during the session 1922–1923: Telford medals to Mr. H. W. H. Richards (London) and Mr. E. O. Forster Brown (London); a George Stephenson medal to Mr. Asa Binns (London); a Watt medal to Mr. A. B. Buckley, jun. (Winchester); Telford premiums to

Mr. W. A. Fraser (Edinburgh), Mr. S. L. Rothery (Calexico, U.S.A.), Mr. Mark Randall (Johannesburg), and Mr. D. E. Lloyd-Davies (Cape Town); an Indian premium to Mr. D. H. Remfrey (Calcutta); a Manby premium to Mr. F. M. G. Du-Plat-Taylor (London); and a Crampton prize to Mr. F. W. Jameson (Kimberley).

AN appreciation of the scientific work and discoveries by Sir James Dewar was broadcasted by Prof. J. A. Fleming on May 4 from the London station 2 LO. Prof. Fleming first referred to Sir James Dewar's work on the liquefaction of air, oxygen, and hydrogen, and the invention of the silvered vacuum vessel for storing these liquids. Closely related with this work was the discovery of the use of charcoal cooled in liquid air for the production of high vacua. Sir James Dewar also made important discoveries in spectroscopy and in connexion with the production of physiological electric currents by the action of light. His work in chemistry contributed to the invention of cordite, while soap films and their behaviour in dust-free air occupied his attention until the last day of his working life. Sir James Dewar's investigations were undertaken in the first instance purely out of a disinterested desire to increase scientific knowledge, but the results have in nearly every case produced numerous beneficial and practical applications.

AT the annual meeting of the members of the Royal Institution held on May 1, the following officers were elected: *President*, The Duke of Northumberland; *Treasurer*, Sir James Crichton-Browne; *Secretary*, Sir Arthur Keith; *Managers*, Mr. S. G. Brown, Dr. J. M. Bruce, Sir Dugald Clerk, Prof. J. A. Fleming, Sir Richard Glazebrook, Earl Iveagh, Sir Alexander C. Mackenzie, Mr. Robert Mond, Sir Edward Pollock, Prof. A. W. Porter, Lord Rothschild, Sir David Salomons, Mr. W. Stone, Sir Alfred Yarrow, The Right Hon. Lord Justice Younger; *Visitors*, Sir Harry Baldwin, Prof. William A. Bone, Mr. A. Carpmael, Dr. E. Clarke, Mr. E. Dent, Dr. T. W. Dewar, Mr. G. H. Griffin, Mr. W. E. Lawson Johnston, Col. F. K. McClean, Sir Malcolm Morris, Dr. W. Rushton Parker, Mr. W. Peacock, Major C. E. S. Phillips, Mr. H. M. Ross, and Mr. S. Skinner. Sir J. J. Thomson has been elected honorary professor of natural philosophy, and Sir Ernest Rutherford professor of natural philosophy. The Duke of Northumberland has nominated the following gentlemen as vice-presidents for the ensuing year: Dr. Mitchell Bruce, Lord Iveagh, Sir Edward Pollock, Lord Rothschild, Sir Alfred Yarrow, The Right Hon. Lord Justice Younger, Sir James Crichton-Browne (Treasurer), and Sir Arthur Keith (Secretary).

A CATALOGUE (No. 259) of books in all branches of chemical science and technology, including the textile industries and agriculture, has just been issued by Mr. W. Bryce, 54 Lothian Street, Edinburgh. It should be very useful for reference. The same bookseller also issues a short list of second-hand books in technology, the classics and general literature, surplus government stock, which are offered at greatly reduced prices.

Our Astronomical Column.

THE APRIL METEOR SHOWER.—Mr. W. F. Denning writes: "This event occurred on the nights of April 21-23. The weather, however, was not very favourable on the night of expected maximum, April 21, and few meteors could be seen owing to clouds. The special display of Lyrids supplied nearly half the total number of meteors observed on the three nights, and the radiant point was in the usual position at about $272° + 33°$.

"It sometimes happens that when the Lyrids are not very abundant, meteors generally are very scarce, and this appears to have been the case on the recent occasion, the hourly rate of apparition being only 3.

"There are a considerable number of radiant points in activity at this period of the year, but the great majority of them are extremely feeble, and an observer must watch the sky for a long period before they may be recognised. Two meteors seen on April 20 last were each recorded at two stations and the paths indicate radiants at $271° + 35°$ and $310° + 59°$."

TEMPERATURE AND DENSITY OF THE UPPER ATMOSPHERE DEDUCED FROM METEORS.—Prof. F. A. Lindemann and Mr. C. M. Dobson contribute a paper on this subject to Proc. Roy. Soc. (Series A, vol. 102, No. A 717). They deal with the large number of doubly observed meteors discussed by Mr. Denning, and give reasoning which leads to the conclusion that during most, if not all, of the meteor's visible track, the molecules of air impinge on a layer of compressed air in front of the meteor. Evaporation goes on from the surface of the meteor, and in general the meteor is wholly consumed long before reaching the ground. Long-enduring trains are explained as the slow recombination of ions separated by the energy of the meteor. The meteors are shown to be very small particles. One as bright as a star of the first magnitude would be 1 mm. in diameter. One as bright as the moon would be 2·5 cm. in diameter (mass 62 gm.). Discussion of the observed phenomena on these lines leads to determinations of the temperature and density of the air at different heights. It is concluded that the isothermal layer, already discovered by *ballon sondes* to extend to a height of 25 km., goes on up to 50 km.; but that above that height the temperature again rises to 280° or 300° abs. The density of the air at 100 km. (about the lower auroral limit) comes out 100 times that previously assumed; it is suggested that it may not be hopeless to reproduce the auroral spectrum in the laboratory, if the corresponding density is 10^{-8} instead of 10^{-10}.

It is suggested in explanation of the high temperature of the upper air that it is largely composed of ozone, which is heated by the infra-red radiations from the earth.

Prof. Lindemann describes in Mon. Not. R.A.S. for January a method which he is using of photographing meteors simultaneously at stations some distance apart, so as to get their height very accurately in order to apply a more rigorous check to his conclusions.

Research Items.

A ROMAN FORTIFIED HOUSE NEAR CARDIFF.—In the Journal of Roman Studies (vol. xi. Part i), Mr. R. E. M. Wheeler gives an elaborate account of a fortified Roman villa, about two miles west of the west bank of the river Ely, at the point where that river, though still tidal, first becomes fordable. He concludes that about A.D. 300 this work fell into line with the general defensive and offensive activities of the period. At a time when Romano-British towns seem to have built or strengthened their walls as the Welsh tribesmen did, it is not unnatural that a private householder should have followed the same example on a smaller scale. It is indeed rather matter for remark that other examples of domestic fortification in the late Roman period have been so rarely observed or recorded. The closest analogy is perhaps the partially excavated house and baths within the Castle Dykes near Ripon.

AN OLD-WORLD CUBIT IN AMERICA.—In *Ancient Egypt*, Part iv. 1922, Prof. W. M. Flinders Petrie directs attention to excavations made by the School of American Research at Santa Fé, New Mexico, where the measurements of buildings indicate a unit of 20·7 inches. This figure accords exactly to the well-known Egyptian cubit: 20·62 in the best early examples, 20·65 in later cubit rods, 20·76 on the Roman Nilometers. Babylonia had a rather longer type, 20·88 in. for the cubit of Gudea's plotting scales, and this was also the standard of Asia Minor, 20·6 to 20·9, with a mean of all of 20·63 in. "How could this reach New Mexico? It was evidently Asiatic. We have evidence from weights of an Asiatic diffusion of a Babylonian original over India, China, and Etruria. If the cubit similarly passed to China, it might thence reach North America. It has been already pointed out how the cross at Palenque (Southern Mexico) was in its detail of ornament derived from Italian crosses of about the eighth century, probably carried to China by the Nestorian mission. By the same route the Asiatic cubit may have passed over to the New World at some earlier period."

MARRIAGE CUSTOMS IN MEDIEVAL INDIA.—In a paper published in the last issue of the Bulletin of the School of Oriental Studies, Sir G. Grierson directs attention to an epic still recited in Northern India describing the war between the Rajputs of Bundelkhand and Delhi. When a Raja had a marriageable daughter he used to send a challenge to neighbouring Rajas, who attacked him, and the contest for the bride was accompanied by serious loss of life on both sides. No exact parallel to this custom has been traced, and it looks as if the bard had exaggerated the details of the mock fight which occurs on the occasion of a wedding. The view that this is a survival of marriage by capture is now generally abandoned, and anthropologists are disposed to believe that the mock fight is a symbol of a contest between the powers of good and evil. The final victory of the good spirits is carefully arranged beforehand, and thus the fertility and happiness of the union is assured.

SUBMARINE WEATHERING OF ROCK-MATERIAL.—K. Humnel of Gieszen (*Geologische Rundschau*, vol. 13, p. 40, 1922) gives the name "halmyrolysis" to the processes of decay and reconstruction, akin to weathering, that go on in rock-material on the floor of seas and oceans. He gives special attention to the origin of glauconite, and attributes its absence from freshwater deposits to the facts that the salts in sea-water are essential to the reactions that build it up, and that certain marine bacteria also play a part. The organic matter, the humic acid, and the energy of oxidation on sea-floors are not sufficiently different from those in lakes to account, as others have suggested, for the absence of glauconite from fresh waters. We may hope that the author will expand his views (p. 102) on phosphatisation on the sea-floor, which he regards as beginning with the absorption of phosphorus by gels consisting of calcium carbonate. The colloidal character of the material for which A. F. Rogers has recently revived the name of "collophane" (see NATURE, vol. 110, p. 292), might thus be an inheritance from previous colloidal calcium carbonate; but this would not account for the widely spread "halmyrolysis" of marine oozes and limestones without loss of the intimate structures of their shelly constituents, which were deposited as crystalline material.

TERTIARY BRACHIOPODA OF JAPAN.—Ichirô Hayasaka, whose papers on the Palæozoic Brachiopoda of Eastern Asia and the Permian Brachiopoda of Japan we have already had occasion to refer to (NATURE, July 29, p. 161, and December 2, p. 749, 1922), has now dealt with the Tertiary Brachiopoda of Japan (Science Reports, Tôhoku Imp. Univ., Sendai, Second Series (Geology), vol. ii., No. 2). While the waters of the Japanese Islands are notoriously rich in these forms, no fewer than thirty-seven species of "lampshells" being recorded therefrom, only thirteen species and five varieties figure in the present monograph, one species and four varieties being believed to be new. Of the eighteen forms, seven are only known fossil, seven are found living in Japanese waters, while the remainder now inhabit distant regions. The occurrence in Japan of *Terebratulina septentrionalis* in the fossil state, indeed, seems to be the first recorded instance, and that, since it is to-day an Atlantic form, is the more remarkable. In an appendix one other species and another variety are recorded as coming from the Pleistocene. These last are apparently additional to the three previously recorded from beds of that age near Tôkyô in 1906.

THE INNER STRUCTURE OF ALLOYS.—The thirteenth annual May lecture of the Institute of Metals was delivered on Wednesday, May 2, by Dr. W. Rosenhain. Referring to the great accumulation of facts in regard to the properties and microstructure of alloys which have been forthcoming in recent years, Dr. Rosenhain considers that it is most desirable that there should be found a key to this maze of knowledge in the form of a general theory that will link together the mass of facts into a homogeneous whole. Such a theory is put forward, based upon the intimate knowledge of crystal structure acquired by X-rays analysis. The crystal structures found in pure metals are modified in the case of alloys, particularly in those called solid solutions, where a second kind of atom enters into the structure of the crystal and produces in it certain minute changes. Especially important is the connexion between the minute distortion of crystal structure which occurs in alloys and the behaviour of alloys on melting and freezing, while such phenomena as plasticity, diffusion, and others fall easily into line with the same type of explanation. This new theory of alloy structure is said to afford a ready explanation of the electrical properties of metals and alloys and the changes of those properties when the metal is heated or cooled, and cover the phenomena of superconductivity found in many metals when cooled nearly to the absolute zero of temperature.

WEATHER RESEARCH ON THE KERMADEC ISLANDS.—The *New Zealand Journal of Science and Technology*, vol. v. No. 5, contains an article by Mr. D. C. Bates, director of the Dominion Meteorological Office, Wellington, on the above. The chief feature of the article is an effort to stimulate the acquiring of Sunday Island, the largest of the Kermadec Group, for a meteorological station, which it is maintained would improve the weather forecasting for New Zealand. It is shown that cyclonic disturbances commonly influence the weather at Sunday Island a couple of days or so before being felt in New Zealand or the adjacent waters. The island was first discovered in 1788 and was partially frequented by settlers in 1837, but calamities which have occurred suggest the question whether it is worth while occupying apart from weather reporting. The island is apparently of volcanic origin, and earthquakes occur about once a month. It is mountainous, with few flat surfaces; water is not easily procurable, and it is out of the track of vessels. The rainfall is said to be by no means deficient. Meteorological observations taken for nine months in 1908 show a total rainfall of 66·26 in. during the period; the heaviest monthly fall was 11·30 in. during April, the least, 3·91 in. during September. The highest temperature in the shade was 85° F. in February, the lowest 46° F. in August. Easterly winds predominate from February to May, and westerly winds from June to October. No observations are available for November, December, and January.

THE DELAY OF VISUAL PERCEPTION.—The issue of the *Optician and Scientific Instrument Maker* for April 20 contains an article by Mr. F. G. Smith which summarises the recent work of Prof. Pülfrich on the effect of brightness on the time which elapses between the formation of an image on the retina and its perception by the observer. If an object moving across the line of vision from left to right is viewed with the right eye direct and with the left through a smoked glass to diminish the brightness of the image formed on the left retina, there is a delay in perception in the case of each eye, but the delay for the left eye exceeds that for the right, and the body appears to the left of and behind the actual position it occupies. If the object is moving from right to left it appears for the same reason to the right and in front of the actual position. If it moves alternately to right and left it appears to describe a circular motion about its mean position. The experiment is easily done with a fixed and a moving pencil, and it is rather remarkable that the phenomenon has not been observed previously.

BRITISH SURVEYING INSTRUMENTS.—Several recent improvements in the design and construction of British-made surveying instruments are detailed and illustrated in a paper by W. H. Connell in the Proceedings of the South Wales Institute of Engineers, vol. xxxix. No. 1, March 15, 1923, which has been reprinted in pamphlet form by Messrs. Cooke, Troughton and Simms, Ltd., Buckingham Works, York. Modern manufacturing methods involving the extensive use of jigs render possible the attainment of great accuracy and uniform production of the parts of instruments. The use of new and improved alloys has diminished the wear of moving parts, and thus instruments retain their adjustments for longer periods. Changes in design have led to the elimination of many adjustments, only one being necessary or provided in many modern levels, namely, that for securing parallelism between the line of sight and the tangent to the curve of the bubble tube. By the adoption of the internal focussing telescope collimation errors are almost entirely eliminated, and the use of accurately fitting removable cells permits of the graticules being cleaned or exchanged without disturbing the collimation adjustment. Changes have been introduced also with the view of saving time and labour in taking readings. For, example, the bubble, compass, and staff can all be read from the eye-end of the telescope without change of position on the part of the surveyor, and the focussing screw is easily accessible no matter what position the telescope may be in.

LITHIUM CARBIDE AND HYDRIDE.—In the *Comptes rendus* of the Paris Academy of Sciences for April 9 MM. A. Guntz and Benoit give an account of some properties of a mixture of lithium carbide and lithium hydride. This homogeneous mixture can be obtained either by heating metallic lithium in ethylene or by dissolving lithium carbide in fused lithium hydride. Submitted to electrolysis this fused mixture gives an abundant deposit of amorphous carbon. This may arise from a true electrolysis of the carbide or by a secondary reaction between hydrogen from the electrolysis of the hydride and the lithium carbide. From the results of their experiments the authors are inclined to regard the first view as the correct one, the lithium carbide being ionised into its elements in the hydride solution. The minimum electromotive force required to produce the carbon deposit is about 0·05 volt.

VULCANISATION OF RUBBER.—Mr. V. V. Byzov, in the Journal of the Russian Physical and Chemical Society, 1921, vol. 53, gives an account of work he has carried out on the vulcanisation of rubber. The researches indicate that the processes of hot and of cold vulcanisation are essentially the same, and are of extreme complexity. Vulcanised rubber consists of four components, which may exist in varying proportions in different samples of rubber. The first component is crystalline sulphur, which can be extracted from the rubber by boiling acetone. In a specimen of rubber containing 2·86 per cent of sulphur, 1·57 per cent was of this type. Most of the remaining sulphur is adsorbed in the rubber, and is in the amorphous plastic condition, this form of sulphur being insoluble in acetone. While plastic sulphur, under ordinary conditions, soon crystallises, in the fine state of division in which it occurs in rubber, conditions are perfect for supercooling, as each globule of sulphur is enclosed in a protective coat of colloidal material. To this plastic sulphur is ascribed the superior elasticity of vulcanised rubber. The rubber itself undergoes isomeric change to an insoluble form, from which a hydrochloride more stable than that obtained from ordinary rubber may be prepared, and the ozonide of which gives, on hydrolysis, not lævulinic aldehyde, as does that of natural rubber, but diacetyl propane. Whether this difference is due to a different degree of polymerisation of the isoprene molecules, or whether a transposition of the double linkages has occurred, it is not possible definitely to state. The fourth constituent of vulcanised rubber is a polymorph of isoprene disulphide $[C_{10}H_{16}S_2]_n$, but this is not as a rule present to any great extent. Thus vulcanisation of rubber is not a reversible process, and the problem of the recovery of pure rubber from an already vulcanised material, important in the waste rubber utilisation industry, appears to be an impossible one, as no means are known whereby the insoluble isomeride of rubber can be converted into the natural form.

The Forthcoming Pasteur Centenary Celebrations at Strasbourg.

WE have already announced that the Government of the French Republic has desired to commemorate this year the centenary of Louis Pasteur, and Strasbourg, where this illustrious savant commenced his scientific and university career, has been very fittingly chosen as the scene for the celebrations. Chief among these will be an international scientific exhibition—L'Exposition Internationale du Centenaire de Pasteur—which has been organised with the object of setting forth the fruits of Pasteur's work, not only in the domain of medicine but also in those of industry and agriculture. This exhibition will be officially opened on June 1 in the presence of the President of the French Republic, members of the French Government, and scientific delegates from all over the world. On the same day a monument erected to the honour of Pasteur in the Place de l'Université will be inaugurated, and a further permanent memorial is to take the form of a Museum of Hygiene. This will consist of a collection of exhibits illustrative of the various researches of Pasteur, and will constitute a history, in concrete form, of the early years of the science of microbiology.

The International Exhibition promises to be a most extensive and complete demonstration of the manifold results of Pasteur's work, both in pure and in applied science. It is to be organised in twelve groups, namely, microbiology, chemistry and chemical industry, collective hygiene, general hygiene, physical training, town hygiene, alimentary hygiene, food industries, refrigeration, agriculture, silks and sericulture, and finally a group devoted to scientific literature. In order that the exhibition should attain to that plane of excellence which would make it at once worthy of the man in whose honour it is being held, and an attraction to men of science, the organisation of the various groups and their sections has been entrusted to those who, by their work, are specially qualified in the various branches of science represented.

The groups of microbiology and collective hygiene are naturally the largest and perhaps the most interesting. The former, under the presidency of Dr. Roux, comprises in all nine sections. There will be a section devoted to diseases of man, including bacteriological and immunological technique, and sections dealing with vaccinia and vaccine institutes, tropical diseases and hygiene, diseases of plants, veterinary diseases, diseases of silkworms and other insects, parasitic insects, nitrification and sterilisation of soil —a most comprehensive list. The group of collective hygiene, with its six sections, is to deal with matters of the greatest importance, such as industrial diseases, tuberculosis, venereal diseases, cancer, maternity and infant welfare, military hygiene, and the organisation and installation of hospitals; and the names of such well-known scientific men as Dr. Calmette and Dr. Louis Martin, among the presidents of these sections, is a guarantee of the standard of excellence which will be reached in this group. But it is not only the man of science who will find interest in this exhibition. The sciences of chemistry and microbiology find their application throughout industry and in all phases of our modern civilisation. It is one of the objects of this exhibition to emphasise this interdependence of science and industry, and, to judge from the list of industries which will be represented by exhibits in the various groups, this aspect of the question has not been overlooked.

The exhibition will remain open till October, and during this period congresses on various subjects are to be held. In this manner it is proposed to discuss such subjects as tuberculosis, housing, town hygiene, cancer, leprosy, syphilis, puerperal fever, and milk. The general secretary of the exhibition is Prof. Borrel, director of the Institute of Hygiene and Bacteriology of Strasbourg.

Chemical Characteristics of Australian Trees.

MR. HENRY G. SMITH, of Sydney, in his presidential address to the section of Chemistry at the meeting of the Australasian Association for the Advancement of Science, held at Wellington in January last, dealt particularly with the elucidation of some chemical characteristics of Australian vegetation, treating the subject in relation to the generalisations that may reasonably be advanced from the consideration of the results secured by the phyto-chemical study of the principal Australian genera, such as Eucalyptus and Callitris. This study extended over a period of more than thirty years, and was undertaken in conjunction with his botanical colleague, Mr. R. T. Baker.

Some of the chemical peculiarities brought to light during this investigation appear to be characteristic of this unique flora, and indicate a distinct uniformity in progressive characters, suggesting evolutionary processes as the directing influence in the production of the numerous groups and species which, in the aggregate, go to form the more important genera.

The genus Eucalyptus apparently originated in what is at present the western and north-western portions of Australia, and as it spread eastward and experienced varying degrees of soil and climate the conditions demanded by these new locations and climatic changes were met by the responding characteristics of the genus.

The chemical peculiarities of nearly two hundred distinct species were determined, so that many data were obtained upon which to formulate the more recent theories regarding the formation of the distinctive groups.

Eucalyptus is essentially an oil-producing genus, and already about forty distinct chemical constituents have been isolated and characterised. These include 11 alcohols; 9 aldehydes; 2 phenols; 7 esters; 5 terpenes; 1 ketone; 1 sesquiterpene; 1 paraffin; and also cymene and cineol.

The two main factors controlling the chemical sequence throughout the genus may be stated in the following terms: (1) The same species of Eucalyptus has chemical properties of a comparatively constant nature wherever found growing under natural conditions, and (2) each constituent follows the sequence of species in increasing amount until a maximum is reached in one or more of them.

These conditions are not only true for the several oil products, but may also be applied to the astringent exudations or kinos produced in varying amounts by all the species. The characteristic features of these exudations are traceable right through the genus, and are particularly noticeable with the two crystalline substances, aromadendrin and eudesmin, found in the older species of the genus. These substances become extinct when the group of "ironbarks" is reached in the sequence of evolution, and are, of course, absent in all the more recent species, such as those belonging to the "stringybarks," "peppermints," "ashes," etc. Eudesmin is a particularly interesting substance, and occurs in the kinos of some species to the extent of ten per cent.

The address also dealt with the chemical peculiarities of the Australian Coniferæ, and in addition with the inorganic constituents peculiar to Eucalyptus trees, instancing the small amounts of mineral matter secreted in the timbers of those species which often occur as very large trees, such as *E. regnans*, *E. pilularis*, etc., a condition that suggests the reason for their continued growth and great size.

The occurrence of manganese, and its importance, were also discussed, the conclusions being based upon the results of much experimental work. It was shown fairly conclusively that the presence of manganese in such minute quantities cannot be considered as accidental, but a necessary constituent for successful growth of these trees, and that some species belonging to certain groups require a larger amount of manganese than is necessary for the growth of those belonging to other groups. The whole question evidently hinges around the action exerted by the enzymes in the structural formation of forest trees and their chemical constituents, and is thus a subject requiring long-continued chemical research and experiment before a reasonable solution of the problem can be expected.

Sunshine-Recording.

IN the sunny southern countries of Europe less general interest appears to be taken in the recording of sunshine duration than is the case in England, where a certain therapeutic importance is attached to an allotment of sunshine which in winter undoubtedly falls below the optimum, although probably not to a greater extent than it rises above the optimum during a Mediterranean summer. However this may be, it is interesting to find the subject discussed in a short article by Guilio Grablovitz in the comparatively new Italian publication *La Meteorologia Pratica* for July and August 1922.

Various objections are raised to the continued use of the Italian words *insolazione* and *soleggiamento* to denote sunshine, the term *eliofania* being advocated instead, which would be anglicised to *heliophany*. It appears that the two former terms have medical significance in connexion with bad and good effects of exposure to the sun, from which our corresponding word "insolation," which is virtually equivalent to the more familiar "sunshine," is free.

Discussion in the paper turns upon the proper dates for replacing the equinoctial card by the summer and winter ones in the well-known Campbell-Stokes sunshine recorder, in which the sun's rays, focussed by a glass ball, leave a charred record. It is argued that the dates officially adopted for the change, namely, February 22, April 20, August 23, and October 22, when the declination of the sun is 12°, might with advantage be altered to March 1, April 11, September 3, and October 15, when the declination is 8°; because in the latter case, during the passage of the sun through a range of 47° between the solstices, the equinoctial, summer, and winter cards would each be used through an equal range, approximately of 16° ($16 \times 3 = 48$), whereas in the adopted practice the equinoctial card covers a range of 24° ($12 \times 4 = 48$). This is a purely technical point to be settled by reference to the design of the instrument; but on wider grounds, astronomical and climatic, the dates actually adopted seem more natural because, the solar declination being then 12° N. or S., that is, practically half-way between 0° and $23\frac{1}{2}$° N. or S., they mark what should be regarded as the real boundary between the solstitial and equinoctial periods of the year.

In connexion with sunshine-duration recorders, one can scarcely refrain from commenting upon the inadequate character of instruments which give no information about the quality or intensity of the recorded sunshine, and from expressing the hope that these will gradually be superseded by radiographs like the Callender recorder and Ångström pyrrheliometer, which indicate the amount of solar energy received in a given time. Such radiographs may not be all that is desired, but at least they show the difference between the intensity of insolation on different days, at different seasons, and in different latitudes or altitudes. They can, for example, differentiate in comparable measured terms between the fitful sunbeams of December and the fiery rays of June; or show, again, that a hot day in England with, say, an air temperature of 90° F. is thermally less fierce than a day in Italy having the same air temperature but under a force of insolation unknown in Northern Europe. The point is that equivalent air temperatures are not truly climatically equivalent unless associated with the same intensity of insolation, and it is well known what an important factor in the economy of living creatures is the direct radiation of light and heat. L. C. W. B.

Trieste and Marine Biology.

DR. M. STENTA, director of the Natural History Museum in Trieste, delivered an address, in October 1921, at the Trieste meeting of the Italian Society for the Advancement of Science, on the important part played by Trieste in the study of marine biology, and the address has recently been published (*Atti Soc. Ital. Progr. Sci.*).

Dr. Stenta referred to the observations of Abbot Fortis published in 1771 on the islands of the Quarnero, and those of Abbot Olivi (1792), who gave, in his "Zoologia Adriatica," a catalogue of the animals of the Gulf of Venice. Almost all the naturalists who visited Trieste in the first half of last century were German; of these, two may be named—I. L. C. Gravenhorst, who recorded (1831) the results of his studies on various molluscs, echinoderms, and Anthozoa; and J. G. F. Will, who gave an account (1844) of the anatomy of Scyphozoa, ctenophores, and siphonophores. K. E. von Baer came in 1845 from Russia to Trieste to search for larvæ of echinoderms, but the results in that and in the following year were not very satisfactory. His visit, however, was fruitful in another respect, for he encouraged Koch, a young Swiss merchant resident in Trieste and an ardent collector, in his project of founding a museum of the Adriatic fauna, which became the centre of studies on the Gulf of Venice. Johannes Müller spent the autumn of 1850 in Trieste working on the development of echinoderms and worms, and in the neighbouring bay of Muggia he discovered in *Synapta digitata* the parasitic mollusc *Entoconcha mirabilis*.

Among many who worked at the museum between 1850 and 1870 were Oscar Schmidt, who carried on researches on sponges; A. E. Grube, who examined the annelids and discovered the parasitic rotifer *Seison nebaliae*; and Kowalevsky, who described (1868) the remarkable sexual dimorphism in *Bonellia viridis*. In 1874 the Adriatic Society of Natural Science was founded, and the 27 volumes of its Bulletin are rich in observations on the biology of the area.

In 1875 the Institute of Marine Biology was established by the Austrian Government, and many famous naturalists have worked in its laboratories, *e.g.* Metschnikoff, on intracellular digestion and phagocytosis; Kowalevsky, on medusæ; Driesch, on the development of isolated blastomeres; the brothers Hertwig, F. E. Schultze, K. Grobben, and Hatschek.

In 1900 the zoological station was enlarged and reorganised under the new director, Prof. C. I. Cori. A list of the more important investigations carried on at the laboratory from that time until 1915 is given by Dr. Stenta, but it is too long to quote here. Mention may, however, be made of Friedländer's investigation of the constitution of the purple secretion of Murex, for which 14,000 specimens were collected; Heider's work on the development of Balanoglossus; and Przibram's researches on regeneration in Crustacea. There were also several investigations in applied zoology: the culture of sponges, the coral fishery, and parasitic protozoa of fishes.

We gather from the concluding part of the address that the Italian Royal Committee for Marine Investigation, which took over the zoological stations at Trieste and Rovigno, proposes to suppress the former, and Dr. Stenta puts forward a plea for its retention.

Animal Nutrition.[1]

TWO series of Research Bulletins which have recently reached this country from America provide remarkable examples of the laborious—one may almost say meticulous—methods which distinguish much of the work now being conducted at the Agricultural Experiment Stations in the United States. The bulletins in question come from the stations attached to the Universities of Missouri and Minnesota respectively. In both cases the aim was to find out by actual chemical analysis the constitution of the bodies of cattle at various ages. In the case of the Minnesota investigations, sixty-three bullocks, at all ages from three months to two years and over, were slaughtered and analyses made of the bodies, not merely as a whole, but under such divisions as flesh, offal, skin, blood, etc. In the case of the Missouri investigations, thirty animals were slaughtered and analysed in much greater detail. Separate figures for all descriptions of edible joints and for each organ of the body are given. It does not require much acquaintance with chemical routine to realise the extraordinary labour involved in reducing the separate parts of the body of an animal to a fine pulp from which uniform samples of every description of tissue can be drawn. So far as this country is concerned, the attempt has been made only once—by Lawes and Gilbert many years ago—and then with difficulty three animals in all were completely analysed.

The object of these investigations may be stated very simply. The animal food consumed by man represents vegetable food converted by stock into "meat." It is desirable to know the extent of the waste involved in this process of conversion. Incidentally, we also wish to know the relation between the amount of this waste and the age of the animal, progressively. The older and larger the animal, the greater the waste, and consequently the more costly the product. Above all, it is desirable to ascertain the relation between protein consumed and protein stored, for the most costly food of all is vegetable protein, supplied in the form of costly oil-cakes; furthermore, as the raw material is generally imported from abroad, the economic loss in Great Britain is very great. There can be no doubt that, as matters stand, millions of money are being wasted by farmers in bringing beasts to a state of fatness required neither by the taste of the modern consumer nor by the human body's need for fat. The supplies of cheap vegetable carbohydrates, from which animal fat can be manufactured, are now greater than they were in our grandfathers' time, but the farmer still goes on producing from imported feeding-stuffs rich in protein, animal fat in wasteful quantity. More than 30 per cent. of the body weight of a "fat beast" is merely fat. Thanks to the labours of these American workers, this point can now be driven home. We can trace at every stage of an animal's growth what happens to the food it consumes, and how as it grows older its conversion factor grows smaller, until, ultimately, it stores only one-twentieth of what it consumes: how again it turns a larger proportion of costly protein into fat, rejecting more and more of nitrogenous matter.

In these days when, we are told, British agriculture is faced with ruin, it is unfortunate that agriculturists apparently cannot be persuaded to give up one of the most costly and wasteful processes of their industry. It is not the farmer alone who is to blame. Both the butcher and the housewife conspire to maintain the demand for excessively fat meat, and while the market demand is for fat stock, it is only to be expected that the present extravagant system of "fatting" beasts will continue.

[1] Studies in Animal Nutrition; University of Missouri, Research Bulletins, 53 *et seq.* Investigations in Beef Production, University of Minnesota, Bull. 193.

University and Educational Intelligence.

BIRMINGHAM.—Announcement is made of the Walter Myers studentship (value 300*l.* for one year) for research in any branch of medicine or pathology approved by the selection committee. The studentship is tenable at any approved university, laboratory, or other institution in the United Kingdom. Candidates may be of either sex, and must be graduates in medicine of the University of Birmingham of not more than five years' standing. The holder of the studentship will be required to devote his whole time to research. Further information may be obtained from the Dean of the Medical Faculty of the University.

CAMBRIDGE.—As announced in our issue of May 5, p. 621, a fund has been established by the family of the late Henry P. Davison, of New York, for the purpose of giving English University men a year's residence and study in the American Universities of Harvard, Yale, and Princeton. Three of these scholarships will be available for next year for Cambridge. The scholars will be selected from undergraduates or bachelors of arts now in residence, the election being on the basis of character, scholarship, and fitness to represent the University. There is to be no examination.

LEEDS.—In memory of the 326 members of the University who fell in the War, a piece of sculpture by Mr. Eric Gill, which will be fixed to the outer wall of the University Library, will be dedicated at the University on Friday, June 1. The University owes this impressive memorial to the generosity of the late Miss Frances Cross of Coney Garths, Ripon.

London.—Prof. E. D. Wiersma of the University of Groningen will deliver a free public lecture on "The Psychology of Epilepsy" at 5.15 o'clock on Thursday, May 24, in the Robert Barnes Hall, The Royal Society of Medicine, 1 Wimpole Street, W.1. The lecture will be in English.

Manchester.—The following resignations are announced: Dr. A. V. Hill, from the Brackenbury chair of physiology, on appointment to the Jodrell chair of physiology in the University of London; Mr. J. P. Headridge, from the lectureship in dental metallurgy; and Dr. J. Gray Clegg, from the lectureship in ophthalmology.

Arrangements are being made for broadcasting University public lectures by joining up the University with the Metropolitan Vickers Broadcasting Station.

It is stated by the Hong-Kong correspondent of the *Times* that Sir Catchick Paul Chater has presented a sum of 30,000*l*. as a contribution towards the general purposes of the University of Hong-Kong.

The Ramsay Memorial Trustees will, at the end of June, consider applications for two Ramsay Memorial fellowships for chemical research. The value of the fellowships will be 250*l*. per annum, to which may be added a grant for expenses not exceeding 50*l*. per annum, and one will be limited to candidates educated in Glasgow. Full particulars as to the conditions of the award are obtainable from Dr. Walter W. Seton, Secretary, Ramsay Memorial Fellowships Trust, University College, London, W.C.1.

The Board of Education has just published a list of fifty-two holiday courses, which will be held at different times during the present year but mostly in the summer months. Nineteen of these courses are organised by Universities and University Colleges (of which nine are held in connexion with the tutorial classes of the Workers' Educational Association), seven by Local Education Authorities, and the remaining twenty-six by various educational bodies. In addition to general courses for teachers there are special courses, among which are the following: economics, gardening, geography, geology, handwork, international relations, languages, librarianship, medieval and modern universities, mine-surveying, physical training, psychology, social service, speech training, and the Victorian Age. The dates of each course, the fees, principal subjects of instruction, address of Local Secretary, and other details are given with each entry. This list can be obtained direct from H.M. Stationery Office, Imperial House, Kingsway, London, W.C.2, or through any bookseller, price 6*d*.

Examination and inspection of secondary schools in the United States are undertaken by several independent and, in many cases, overlapping agencies, namely—State officers of education, universities or colleges, and accrediting associations such as the Association of Colleges and Secondary Schools of the Southern States, the New England College Entrance Certificate Board, and the North Central Association of Colleges and Secondary Schools. In 1913 the United States Bureau of Education prepared a directory of schools (more than 13,000) which had satisfied or been "accredited" by these various agencies as equipped for preparing students for colleges requiring 15 "units" for unconditioned admission, and a fourth edition of the directory has recently been published as Bulletin, 1922, No. 11. The definitions of standards involved in the processes of "accrediting," as set out in the Bulletin, are instructive. One on which the various agencies are all agreed is the above-mentioned "unit" of measurement of secondary school work: a year's study in any subject, constituting approximately a quarter of a full year's work, on the assumption that the school year is from 36 to 40 weeks and that the study is pursued for 4 or 5 periods (of from 40 to 60 minutes each) per week, it being understood that a satisfactory year's work in any subject cannot usually be accomplished in less than 120 sixty-minute hours or their equivalent. The subjects recognised by the various accrediting bodies vary greatly: the College Entrance Examination Board, for example, permits the inclusion of English, mathematics, languages, history, science, and drawing only, whereas the University of California accepts also mechanic arts, agriculture, home economics, music, book-keeping, and stenography and typewriting. Almost all the State universities specify among their admission requirements three units of English and two and a half of mathematics; nearly half of them require at least one unit of science; more than half require history and foreign languages; only three require a classical language.

"The Rising Cost of Education" in America is one of the main subjects dealt with in the recently published 17th annual report of the president of the Carnegie Foundation for the Advancement of Teaching. During the past thirty years, while the national income increased by 500 per cent., the expenditure for public schools—elementary and secondary—rose by 700 per cent., and for universities, colleges, and technological schools by 1400 per cent. During the last decade the pace of growth increased, and an increasing share of the cost was transferred to the Federal treasury. The people still believe in education, but are becoming somewhat critical as to whether the system for which they are paying is altogether justifying itself in its results; and, in any case, the fact has to be faced that the cost of schools cannot be indefinitely increased: "Education must reckon with economic necessity." So far the president's review discloses a situation identical with that brought to light in Great Britain by the Geddes report. Analysis of the factors shows that in America, as in England, the increase in salaries since the War has been very great, but that in America it has been specially pronounced in the colleges: in the institutions associated with the Foundation, professors' salaries rose in four years by 28-83 per cent. The main purpose of the report, however, is to emphasise the fact that the rise in cost has been largely due to a change in the conception of education itself and the part the school is to play in the social order: to the widespread notion that formal education is not only the one way to advancement but also "the panacea for all social and political disorders"; to the admission to high schools and colleges of great numbers of pupils ill fitted for them; to the so-called "enrichment" of the curriculum with a great variety of subjects in which a mere smattering of knowledge is imparted; to the introduction of vocational training into the high schools; and to "acceptance of the notion of scientific research as the primary object of the college teacher." "Both financial necessity and educational sincerity require a return to a feasible and educationally sound conception of the school."

Societies and Academies.

LONDON.

Royal Society, May 3.—Leonard **Hill** and A. **Eidinow**: The influence of temperature on the biological action of light. The biological action of light is accelerated by warmth and retarded by cold. This is true for bacteria, infusoria and human skin. The temperature coefficient for infusoria, between 1° and 20° C., is about 3·0. By adequate exposure to cool air over-action of the sun on the skin can be prevented. The proven success of heliotherapy applied to children with surgical tuberculosis can probably be secured for cases of phthisis if these are no longer exposed in hot sun-boxes, but suitably stripped and exposed in cool air.—F. A. E. **Crew**: Studies in intersexuality. I.—A peculiar type of developmental intersexuality in the male of the domesticated mammals. Individuals, regarded as females during the earlier part of their lives, later assume the behaviour and the secondary sexual characters of males. They form a series according to the degree of imperfection of the external genitalia and the relative degree of development of the derivatives of the Wolffian and Müllerian ducts. In all there were paired but mal-descended testes. The condition appears to be the result of the absence during the period of differentiation of the sex organisation of that minimum stimulus provided by the sex-differentiating substance, of the sex-hormone, in a zygotic male. The Wolffian and Müllerian ducts pursue an equal and parallel development. The degree of intersexuality varies with the stage during the period of sex-differentiation at which the necessary minimum stimulus was exhibited. Since the assumption of the secondary sexual characters of the male type is normal in time, either the minimum stimulus is ultimately exhibited, or else there is a different threshold of response to the action of the sex-differentiating stimulus on the part of various structures belonging to the sex-equipment.—E. J. **Morgan** and J. H. **Quastel**: The reduction of methylene blue by iron compounds. The restoration of the power to reduce methylene blue to boiled milk by means of ferrous sulphate solution is due to the inorganic constituents of the milk. Methylene blue is reduced by ferrous sulphate solution in the presence of sodium hydroxide, carbonate, bicarbonate or phosphate, and of the sodium salts of acids such as acetic, tartaric, or citric. Ferrous sulphate solution alone will not effect any perceptible reduction. Two ferrous molecules always react with one of methylene blue. The mechanism of the reduction appears to depend on the relative affinities of the oxygen acceptor for the hydroxyl ion and of the hydrogen acceptor for the hydrogen ion.—C. F. **Cooper**: The skull and dentition of *Paraceratherium bugtiense*. A genus of aberrant rhinoceroses from the Lower Miocene deposits of Dera Bugti. A complete lower jaw, a nearly complete skull, parts of three other skulls, several fragments of lower jaws, numerous loose teeth, and parts of the milk dentition found in Baluchistan are discussed. The lower pair of incisors have the form of tusks turned downward. Even in the oldest specimens they show practically no signs of having been used. The condition of the premolar dentition shows the animal to be in an early state of evolution, but on a side line, with some possible connexion with the early North American Aceratheres. Similar teeth were found in Turkestan by Borrissyak and described by him as belonging to Indricotherium (=Baluchitherium), and a skull has been discovered in Mongolia by the American Museum expedition and attributed to Baluchitherium. It has the enormous length of 5 ft., as against a skull length of 3 ft. in the present form, which makes it the more probable that the two genera are properly separated.—W. L. **Balls**: The determiners of cellulose structure as seen in the cell walls of cotton hairs. The use of plane and circularly polarised light and of immature hairs shows that the reversals of the spiral fibrillar structure appear in full number, as soon as the secondary wall is visible, indicating predetermination thereof during growth in length. On development of the pre-cellulose, the primary wall shows a pair of opposed spirals with pitches corresponding to that of the slip spirals of the secondary wall. These slip spirals are structurally connected with the quicker pit spirals and invariably opposed to the latter in direction; the tangents of their angles are in the ratio of 4 : 1, which suggests polymerisation from the pre-cellulose of the primary wall. The rotation of the plane of polarisation by a single layer of secondary cell-wall is inverted on opposite sides of a reversal point; thus the molecular structures of the right-hand and left-hand areas would seem to be mirror-images. The probable space-lattice conformation of cotton and other celluloses seems to indicate a modernised restatement of Nägeli's micellar theory.—I. de B. **Daly**: The influence of mechanical conditions of the circulation on the electro-cardiogram. Exercise in man produces changes in the electro-cardiogram which are similar to those obtained in anæsthetised animals by simultaneous stimulation of both stellate ganglia. Partial or complete denervation of the heart was produced in a dog. Alterations in the mechanical conditions of the circulation were brought about (i.) by partial compression of the systemic aorta at various levels in the body, and (ii.) by changing the conditions of the artificial circulation of the heart-lung preparation. The most marked changes in the electro-cardiogram occurred when the arch of the aorta was partially clamped. The form of the electro-cardiogram of the denervated mammalian heart probably remains unaltered when the increase in work of the heart is produced in a physiological manner.

Zoological Society, April 10.—Dr. A. Smith Woodward, vice-president, in the chair.—G. C. **Robson**: The snail *Planorbis sufourii* Graells, the intermediate host of *Schistosoma* (*Bilharzia*) *hæmatobium*, in Portugal.—C. F. **Sonntag**: On the anatomy, physiology and pathology of the chimpanzee.—K. **Kostanecki**: On a remnant of the omphalo-mesenteric arteries in the manatee.

Royal Microscopical Society, April 18.—Prof. F. J. Cheshire, president, in the chair.—D. W. **Cutler**: The Protozoa of the soil. Data were obtained from 365 consecutive daily counts of the numbers of bacteria and protozoa in a normal field soil. Fourteen-day averages of the total numbers showed marked seasonal changes; the organisms being most numerous in November and fewest during February. An inverse relationship exists between the numbers of bacteria and the active amœbæ. A two-day periodicity obtains for the active numbers of one species of flagellate. Azotobacter, in the presence of Protozoa, can fix more atmospheric nitrogen than when alone. Experiments on the reproductive rate of *Colpidium colpoda* show that, according to the age of the parent culture, death of some of the organisms follows inoculation into fresh medium; also that death occurs even during the period of maximum reproduction.—A. C. **Seward**: The use of the microscope in palæobotanical research. Microscopical investigation can be applied to plants which have been preserved in different states, are of different geological age, and belong to various divisions of the vegetable kingdom, and reference was made to the examination of fragments detached from imperfectly petrified stems which cannot be cut into sections. Petrified roots of a Cretaceous fern were described in illustration of the difficulty of distinguishing between inorganic and organic structures. The architectural basis of plant organs has been remarkably persistent through the ages. Recent palæobotanical discoveries have thrown little light on the problem of evolution.

MANCHESTER.

Literary and Philosophical Society, April 24.—Mr. W. H. Todd, vice-president, in the chair.—T. H. **Pear**: A new type of number form. The numbers appear to be on small square blocks. It is possible, by imaging a series of them tilted backwards, to see at a glance a numerical series like 1, 2, 4, 8, etc., or even 1, $\frac{1}{2}$, $\frac{1}{4}$, . . . $\frac{1}{128}$. To see this last fraction it is necessary, in imagination, to approach the form very closely. Complex numbers like $\sqrt{-1}$ and $\sqrt{-9}$ can be seen vaguely in undefined areas in the neighbourhood of 1 and 9 respectively. The form even represents a billion and a trillion, though it is difficult to see beyond a source of light (to look into which is like looking at the sun) which exists near the place representing a million.—W. J. **Perry**: The neurological basis of human behaviour in society. A calm, happy, peaceful behaviour is normal for man as he is at present constituted. Since this type of behaviour is universal among peoples in the "food-gathering" stage of culture, it must have been acquired at an early stage in the evolution of man, who, in the course of the development of civilisation, has, speaking generally, exhibited war-like, cruel, and angry types of behaviour to an increasing degree. An explanation is sought by considering man's brain as consisting of two distinct parts—the optic thalamus and the cerebral cortex, or neo-pallium. The optic thalamus represents the dominant part of the brain of the lower vertebrates. The cortex is concerned with "epicritic" sensibility, the thalamus with emotional tone. The increasingly violent behaviour of man as civilisation has proceeded can be referred to stimuli, due to certain social institutions, which, by unduly exciting the thalamus, undermine the control established by the cortex. The removal of those institutions should therefore have tremendous effects on human behaviour.

DUBLIN.

Royal Dublin Society, April 24.—Prof. J. A. Scott in the chair.—A. E. **Clark**: Evidence of displacement of Carboniferous strata in County Sligo. Accurate plotting of the igneous dykes on the N. coast of Co. Sligo shows that a strip of country four miles wide, lying just W. of Aughris Head, has been displaced southwards between parallel faults for a distance varying from a quarter of a mile on the W. side to three-quarters of a mile on the E.—E. J. **Sheehy**: The comparative values of protein, fat, and carbohydrate for the production of milk fat. By feeding lactating goats for successive periods with carbohydrate, fat, and protein the relative values of these materials have been ascertained. Protein (in excess of that required for milk protein and for body maintenance) and carbohydrate are equal in value, and fat is $2\frac{1}{4}$ times as valuable as either. In rations containing less than a certain quantity of fat, however, the substitution of extra fat for some of the carbohydrate gives results which credit fat with a value much higher than $2\frac{1}{4}$ times that of carbohydrate. In addition to its food value, fat in the ration stimulates milk fat secretion, but a small quantity suffices for the latter purpose.—T. J. **Nolan** and H. W. **Clapham**: The utilisation of monomethylaniline in the production of tetryl. In the nitration of monomethylaniline, metanitrotetryl is formed in addition to tetryl; also crude tetryl formed from commercial dimethylaniline frequently contains the same impurity. The use of monomethylaniline for the manufacture of tetryl has, apart from its cost, been hitherto regarded with disfavour. Tetryl containing not more than almost inappreciable quantities of metanitrotetryl can be obtained in good yield from monomethylaniline if the latter, before nitration, is converted into its nitroso derivative. The nitroso group influences the course of the nitration.

PARIS.

Academy of Sciences, April 9.—M. Albin Haller in the chair.—A. **Guntz** and **Benoit**: The ionising power of fused lithium hydride.—Maurice **Lecat**: The generalisation and modifications of a theorem of Frobenius.—E. O. **Lovett**: Certain functional properties of conics and their generalisations.—Maurice **Fréchet**: The existence of ($\mathfrak{D}$) classes not complete.—M. **Mandelbrojt**: Taylor's series with gaps.—H. C. **Levinson**: The gravitational field of n bodies in the theory of relativity.—Ernest **Csilser**: Some dynamical and geometrical properties of movement resulting from the conditions of M. Angelesco.—G. **Laville**: The propagation of maintained waves along an iron wire. The experimental results are in good agreement with the formula developed from Maxwell's equations, but the formula deduced from Kirchoff's theory leads to results not in accord with experiment.—G. **Vavon** and A. **Husson**: Catalysis and steric hindrance. A study of the reduction of cinnamic acid and esters and alkylcinnamic acids and esters by hydrogen in the presence of a platinum catalyst. The experimental results are in agreement with the predictions of the theory of steric hindrance. J. F. **Durand**: The action of acetylene on zinc ethyl. Acetylene was passed into a solution of zinc ethyl in petroleum ether, and the yellow solid produced rapidly separated. It gave the reactions of a zinc acetylide; water gave acetylene and zinc hydroxide. Mercury diphenyl treated in a similar manner gave no reaction.—W. J. **Vernadsky**: Mendelejeffite, a new radioactive mineral. This mineral, found near Sludjanka (on lake Baïkal), is a calcium urano-titano-niobate, containing about 23·5 per cent. of U_3O_8. Its crystalline form is described.—Ph. **Schereschewsky** and Ph. **Wehrlé**: Elements of a synthesis of the French and Norwegian methods of weather forecasts.—Ch. **Janet**: The ontogenesis of *Volvox aureus*.—Lucien **Daniel**: Variations of perfumes under the influence of grafting. Experiments on grafting with wormwood (*Artemisis Absinthium*) have shown that the modifications in the leaves and seeds are accompanied by changes in the character of the essential oil: the taste and perfume may improve or deteriorate with differences in the species grafted.—Raphael **Dubois**: Tears and the functions of the lachrymal gland. An enzyme has been isolated from the lachrymal glands of the cow: it is neither an oxydase nor a peroxydase, but is a diastase hydrolysing starch like ptyaline; the name lacrymase is given to it.—M. **Lopez-Lomba** and Mme. **Randoin**: The production of scurvy in the guinea-pig and young rabbit by means of a new food regime, complete and in biochemical equilibrium, deprived only of the factor C. A food is described containing all the necessary constituents except factor C. The animals fed with this ration, plus 3 c.c. of lime juice (factor C), made normal growth. All the other animals fed with the same ration, minus factor C, after a short period of rapid growth, developed scurvy and died.—E. **Lesné**, **Christou**, and **Vaglianos**: The passage into the milk of the C vitamins introduced by other means than the mouth.—E. Fernandez **Galiano**: The rhythmic contractions of Vorticella.—A. L. **Herrera**: The imitation of plasmodia and chromatic structures by sodium silicate coloured with ivory black and drops of alcohol in diffusion. If drops of absolute alcohol are allowed to diffuse into a syrupy solution of sodium silicate coloured with ivory black, remarkable imitations of cells, nuclei, and chromatic structures are produced. The structure can be preserved fairly well by washing the card with weak alcohol to remove traces of alkali.—A. **Policard**: The mineralisation of histological sections by calcination, and its interest as a general histochemical method. The method, described in detail, permits the localisation of the mineral elements in the positions they occupy in the living tissue.—René **Jeannel**: The evolution of the copulatory apparatus in the genus Choleva. The sexual characters in this genus, both in the male and female, are more trustworthy than the external characters in defining the species.—Lucien **Semichon**: The preparation of wine by continuous fermentation: selection of the ferments by the alcohol already formed. Natural fermentation is due to elliptical yeasts, wild and apiculated yeasts, Dematium, spores of cryptogams, and various bacteria, all of which are objectionable except the first. Sterilisation of the must, followed by the introduction of a pure yeast culture, is economically impracticable. In a must containing 5 per cent. of alcohol the growth of the elliptic yeasts is favoured and the objectionable organisms do not develop freely. In practice, the addition of this amount of alcohol is not possible, but the same result can be obtained by a process of continuous fermentation. A portion of the must is started fermenting with a cultivated yeast, and after the necessary amount of alcohol has been produced, fresh must is added at a constant rate. The method has been successfully applied on the large scale.—Auguste **Lumière** and Henri **Couturier**: Barometric depression and anaphylactic shock. Guinea-pigs, sensitised by egg albumen, are partially protected against anaphylactic shock by placing under a bell jar in an atmosphere at about half the normal atmospheric pressure. The mortality in the animals thus treated was 40 per cent. against 80 per cent. when the animals were allowed to remain under normal pressure after the second injection.—Jules **Amar**: The law of vivireaction in pathology.

April 16.—M. Albin Haller in the chair.—Emile **Picard**: The singularities of harmonic functions.—Charles **Richet**: The spleen, a useful organ, but not essential. An account of experiments on the comparative effects of starvation of dogs with and without the spleen. Animals can survive for long periods after removal of the spleen: the experiments prove that animals without the spleen require more food to maintain their normal weight, and die more quickly than normal animals when deprived of food.—M. **d'Ocagne**: Normals of quadrics along their lines of curvature. Charles **Nicolle**, Et. **Burnet**, and E. **Conseil**: The micro-organism of epizootic abortion, distinguished from that of Mediterranean fever by the absence of pathogenic power for man. *Micrococcus melitensis* (the organism of Maltese fever) and *Bacillus abortus* present striking similarities in their morphological characters, cultures, and pathogenic power towards the animals commonly used in laboratory experiments; but *B. abortus* proves to be innocuous to man. Cultures injected into five voluntary subjects caused neither fever nor any other trouble: hæmocultures remained sterile and the agglutinating power was generally not developed.—Georges **Bouligand**: The singularities of harmonic functions.—Gaston **Bertrand**: The problem of Dirichlet and the potential of the simple layer.—G. C. **Evans** and H. E. **Bray**: Poisson's integral generalised.—André **Planiol**: The influence of velocity and of temperature on the friction losses in explosion motors. The engine was driven by an electric motor and the power used measured electrically: in one set of experiments the air port was fully open, in another the air admitted was reduced to a minimum. The frictional losses were found to be a linear function of the turns per minute, the rate of increase being much larger than was expected. Experiments were also made on the effect of varying the temperature of the cooling water.—Wladimir **de Belaevsky**: A problem of elasticity in two dimensions.—M. **Mesnager**: Observations on the preceding communication.—Antonio **Cabreira**: A method of obtaining the geographical co-ordinates at any height of a star.—Charles **Nordmann** and C. Le **Morvan**: Observations of the Pleiades with the heterochrome photometer of the Paris Observatory. A new method for determining stellar parallax by photometry. The photometric measurements given show that, for the stars of the Pleiades studied, there exists a clear relation between the intensity distribution in the visible spectrum and the absolute magnitude of the star.—P. **Noaillon**: Superficial circulation.—M. **Hadamard**: Remarks on the preceding communication.—Albert **Pérard**: Study of some mercury and krypton radiations with the view of their applications in metrology. The results of a large number of comparisons with the red cadmium line are given, with the view of detecting the presence of satellites of feeble intensity. None of the lines compared (neon, krypton, mercury) behaved as a simple symmetrical line.—Léon and Eugène **Bloch**: Spark spectra of higher order. Reply to a claim for priority by M. Dunoyer.—M. A. **Catalan**: Spectrum series and ionisation and resonance potentials of chromium and molybdenum.—L. J. **Simon** and A. J. A. **Guillaumin**: The determination of carbon and hydrogen by the use of a mixture of sulphuric acid and silver bichromate. The principle of the method is the determination of the carbon dioxide produced by heating a known amount of substance with a measured excess of the oxidising mixture, and the determination of the excess by the addition of an easily combustible substance (potassium methylsulphate), and a second measurement of carbon dioxide. Results of the application of the method to ten organic substances of varying types are given.—M. **Lespieau**: Some derivatives of the glycerol $(OH)CH_2 . CH(OH) . C : C . CH_2(OH)$.—A. **Wahl** and W. **Hansen**: Isoindigotine and indine. Isoindigotine has been proved to be identical with Laurent's indine.—M. E. **Denaeyer**: The rocks collected by MM. Chudeau and Villatte in the central Sahara.—E. **Schnaebelé**: The tectonic origin of the valleys of the eastern slopes of the Vosges.—Louis **Besson**: Observation of a parhelion of 90°.—René **Souèges**: The embryogeny of the Valerianaceæ. The development of the embryo in *Valerianella olitoria*.—Pierre **Georgévitch**: The rôle of the centrosome in kinesis.—Mlle. Lucienne **Blum**: Modification of plants submitted to culture under glass. Comparative studies of the same plants grown under glass and in the open air. Under glass the plant appears to be stabilised at an earlier stage of its growth. The organs of secretion are always more abundant in the plant under glass.—Henry **Cardot** and Henri **Laugier**: The adaptation, transmission of acquired characters, selection by vital concurrence in the lactic ferment.—Edouard **Chatton** and Mme. M. **Chatton**: Sexuality provoked experimentally in an Infusoria, *Glaucoma scintillans*. Predominance of the conditions of the medium in its determinism.—Jules **Barrois**: The development of Echinoderms.

CALCUTTA.

Asiatic Society of Bengal, April 4.—M. A. **Wali**: Hinduism according to Muslim Ṣufis. Some Ṣufi scholars of India conclude that India, like other countries, has produced prophets and saints, and that the teachings of the Vedas and Upanishads are in accordance with the Muslim Scriptures.—W. **Ivanow**: A "witch-case" in medieval India. A curious and complete case of sorcery in the form technically called envoûtement from the Siyaru 'l-'Ārifīn (± A.D. 1530) which is translated and annotated.—H. **Mitra**: Epigraphic notes.—H. C. **Robinson** and C. B. **Kloss**: Some remarks on Mr. C. Stuart Baker's new volume on the Birds (second edition) in the "Fauna of British India." A number of corrections are proposed for the Malaisian and eastern Indo-Chinese species dealt with.—Zoological results of the Percy Sladen Trust Expedition to Yunnan in 1922, under the leadership of Prof. J. W. Gregory:—J. C. **Brown**: An account of the country traversed by the Expedition.—N. **Annandale**: Land molluscs. Eighteen species and one local race are represented, of which five species (all belonging to the genus Buluminus or Ena) and one race of *Helicarion resinaceus* Heude are described as new.—B. **Prasad**: Bivalve molluscs. Six species of Corbicula from W. Yunnan, a Unionid and a Sphærium are recorded from Lake Tali.—S. W. **Kemp**: Decapod Crustacea. Three crabs and a prawn of the genus Caridina were collected. One of the crabs is a new species of Potamiscus, while another (*Potamon atkinsonianum*) is interesting as being a Himalayan form. The Caridina from Lake Tali is new and is remarkable on account of the secondary sexual characters of the male.

Official Publications Received.

Abisko Naturvetenskapliga Station. Observations météorologiques à Abisko en 1921. Faites et rédigées par Bror Hedemo. Pp. v+66. (Stockholm: Victor Pettersons Bokindustriaktiebolag.)

Report of the Kodaikanal Observatory for the Year 1922. Pp. 8. (Madras: Government Press.) 6 annas.

Fourth Annual Report of the Governors of the Imperial Mineral Resources Bureau. Pp. 24. (London.)

Medical Research Council. Third Annual Report of the Industrial Fatigue Research Board to 31st December 1922 (including Personal Contributions from Investigators). Pp. 83. (London: H.M. Stationery Office.) 2s. net.

Rocznik Astronomiczny Obserwatorjum Krakowskiego na rok 1923. Tom. 2. Pp. iv+167. (Kraków.) 2s. 6d.

Diary of Societies.

SATURDAY, MAY 12.

ANNUAL CONFERENCE OF THE UNIVERSITIES OF GREAT BRITAIN AND IRELAND (at King's College), at 11.—Sir Theodore Morison and others: Discussion on The Financial Outlook of the Universities.—Sir W. Henry Hadow and others: Discussion on Music as a University Subject.—Sir William H. Beveridge and others: Discussion on the Universities and Training for Administrative and Municipal Life.—A. Greenwood, the Master of Balliol, and others: Discussion on Labour and the Universities.

MONDAY, MAY 14.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—Prof. T. G. Pinches: Assyro-Babylonian Israel Likenesses and Contrasts.

ROYAL GEOGRAPHICAL SOCIETY (at Lowther Lodge, Kensington Gore), at 5.—Prof. J. W. Gregory: The Banda Arc; its Structure and Geographical Relations.

FARADAY SOCIETY (at Chemical Society), at 7.50 (Annual General Meeting); at 8.—E. P. Perman and H. L. Saunders: The Vapour Pressures of Concentrated Cane Sugar Solutions.—E. W. J. Mardles: The Elasticity of Organogels of Cellulose Acetate.—D. Stockdale: An Example of Polymorphism in an Intermetallic Compound.—A. L. Norbury: Some Experiments on the Hardness of Spontaneous Annealing of Lead.—F. C. Thompson and E. Whitehead: Some Notes on the Etching Properties of Alpha and Gamma Forms of Tricarbide of Iron.

ROYAL SOCIETY OF ARTS, at 8.—S. S. Cook: The Development of the Steam Turbine (3). (Howard Lectures.)

TUESDAY, MAY 15.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. A. C. Seward: Arctic Vegetation of Past Ages. (Tyndall Lecture.)

ROYAL STATISTICAL SOCIETY, at 5.15.—D. R. Wilson: On Some Recent Contributions to the Study of Industrial Fatigue.

INSTITUTE OF TRANSPORT (at Institution of Electrical Engineers), at 5.30.—G. J. Shave: The Design and Maintenance of Commercial Motor Vehicles.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Pictorial Group), at 7.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—J. H. P. Murray: Native Administration in Papua.

SOCIOLOGICAL SOCIETY (at Leplay House, 65 Belgrave Road), at 8.15.—Dr. G. Slater: The Psychological Basis of Economic Theory.

WEDNESDAY, MAY 16.

ROYAL METEOROLOGICAL SOCIETY, at 5.—M. de Carle S. Salter and J. Glasspoole: The Fluctuations of Annual Rainfall in the British Isles considered cartographically.—A. W. Clayden: (*a*) An Improved Actinograph. (*b*) Note on the Influence of a Glass Shade.—Capt. E. E. Benest: Notes on the "Sumatras" of the Malacca Straits.

GEOLOGICAL SOCIETY OF LONDON, at 5.30.—W. B. R. King: The Upper Ordovician Rocks of the South-Western Berwyn Hills.—Prof. W. J. Pugh: The Geology of the District around Corris and Aberlleffenni (Merionethshire).

ROYAL MICROSCOPICAL SOCIETY (Industrial Applications of the Microscope Section), at 7.—L. Taverner: The Principles and Application of Technical Metallurgical Microscopy.—W. M. Ames: Applications of the Microscope in the Manufacture of Rubber.

ROYAL SOCIETY OF ARTS, at 8.—L. Gaster: Industrial Lighting and the Prevention of Accidents.

SOCIETY FOR CONSTRUCTIVE BIRTH CONTROL AND RACIAL PROGRESS (at Essex Hall, Strand), at 8.—Earl Russell: Progress and the Law (to be followed by a discussion).

THURSDAY, MAY 17.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. E. G. Coker: Engineering Problems solved by Photo-elastic Methods (1). Improvement in Apparatus; Contact Pressures and Stresses.

ROYAL SOCIETY, at 4.30.—Dr. A. E. H. Tutton: (1) A Universal Interferometer. (2) A Wave-length Torsometer and its Use with the Universal Interferometer.—Prof. L. N. G. Filon and F. C. Harris: The Diphasic Nature of Glass as shown by Photo-elastic Observations.—Prof. C. E. Inglis: Stress Distribution in a Rectangular Plate having two Opposing Edges sheared in Opposite Directions.—Prof T. H. Havelock: Studies in Wave Resistance—Influence of the Form of the Water-plane Section of the Ship.—W. M. H. Greaves: A certain Family of Periodic Solutions of Differential Equations, with an Application to the Triode Oscillator.

INSTITUTION OF MINING AND METALLURGY (at Geological Society), at 5.30.

RÖNTGEN SOCIETY AND THE ELECTRO-THERAPEUTIC SECTION OF THE ROYAL SOCIETY OF MEDICINE (First Annual Joint Meeting) (in the Barnes Hall, Royal Society of Medicine), at 5.30.—Dr. A. W. George: The Pathological Gall Bladder. (Mackenzie Davidson Memorial Lecture.)

CHEMICAL SOCIETY, at 8 (and Informal Meeting).

FRIDAY, MAY 18.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—Discussion.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—W. M. Mordey: Recent Studies in Alternating Magnetism.

SATURDAY, MAY 19.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—J. B. McEwen: Harmonic Evolution.

PUBLIC LECTURES.

MONDAY, MAY 14.

UNIVERSITY COLLEGE, at 5.—Prof. G. Dawes Hicks: Kant's Theory of Beauty and Sublimity. (Succeeding Lectures on May 22 and 28.)

TUESDAY, MAY 15.

GRESHAM COLLEGE, at 6.—A. R. Hinks: Astronomy. (Succeeding Lectures on May 16, 17, and 18.)

THURSDAY, MAY 17.

UNIVERSITY COLLEGE, at 2.30.—Prof. W. M. Flinders Petrie: Recent Discoveries of the British School of Archæology in Egypt. (Lecture repeated on May 23 at 5, and 26 at 3.)

ST. MARY'S HOSPITAL (Institute of Pathology and Research), at 4.30.—Prof. F. G. Hopkins: An Oxidising Agent in Living Tissues.

KING'S COLLEGE, at 5.30.—Principal L. P. Jacks: The Higher Education and the Community of Nations (Hibbert Lecture).

UNIVERSITY COLLEGE, at 5.30.—Prof. H. A. Lorentz: The Rotation of the Earth and its Influence on Optical Phenomena.—Dr. C. Pellizzi: Bernardino Telesio e la filosofia europea (in Italian.)

The Water in the Atmosphere.[1]

By Dr. G. C. Simpson, F.R.S., Director of the Meteorological Office.

THE dictionary definition of "saturation" is "the state of a body when quite filled with another," and it is usual to think of saturated air as air which is full of water vapour to such an extent that further water cannot be added without condensation taking place. This, however, is a wrong conception, for there is no limit to the amount of water vapour which air can contain at any temperature, provided that it is perfectly pure, except that ultimately the molecules of vapour will be so near together that there will be no distinction between vapour and liquid.

Air at 30° C. is said to be saturated when its vapour pressure is 31·51 mm. of mercury, but if to such saturated air we add water in sufficiently small drops it will be evaporated immediately and the liquid drops transformed into invisible vapour. If we could add drops with so small a diameter as $1·6 \times 10^{-7}$ cm. the air would devour them with avidity until its vapour pressure was more than 126 mm., and then would be ready for more if smaller drops could be supplied.

The question of whether air can hold more vapour or not depends entirely on how the water is presented to it. If the water is presented with a flat surface, evaporation will take place until there is so much water vapour present in the air that as many water molecules return to the surface as leave it; the air is then saturated with reference to a flat surface of pure water. If the surface is curved—convex towards the air—more water molecules will leave each square centimetre of the surface than in the case of a flat surface; hence there must be more vapour molecules in the air before equilibrium is attained. Thus the saturation vapour pressure over a curved surface is higher than over a flat surface at the same temperature. On the other hand, if the water contains certain impurities—*e.g.* sulphuric acid, calcium chloride, and salts in general—less molecules leave the surface than in the case of pure water; hence a smaller number of molecules in the air will be sufficient to produce equilibrium over a solution.

In accordance with the usual practice we will describe air as saturated when the water vapour it contains is in equilibrium with a flat surface of pure water at the same temperature. This will define the saturation pressure at each temperature, and relative humidities will be given in terms of this saturation pressure.

It is well known that water can exist in the liquid state at temperatures far below the freezing point, and therefore water and ice may exist side by side over a large range of temperature. But the vapour pressure which is in equilibrium with ice at a given temperature is lower than that which is in equilibrium with supercooled water at the same temperature; that is, air is in equilibrium with ice at a relative humidity below 100 per cent.

Thus, according to our definition of relative humidity, the water vapour in air may be in equilibrium with water over a large range of relative humidities according to the physical state of the water present. The following tables give the relative humidity of air in equilibrium with pure water in the liquid and solid state.

Table I.

Relative humidity of air in equilibrium with water surfaces of various radii at 0° C.

Radius, cm.	Flat.	$1·0 \times 10^{-3}$.	$1·1 \times 10^{-5}$.	$2·5 \times 10^{-6}$.	$7·2 \times 10^{-7}$.	$1·6 \times 10^{7}$.
Relative humidity	100	100·00012	101	105	120	400

Table II.

Relative humidity of air in equilibrium with a flat surface of ice at various temperatures.

Temperature	0° C.	−10° C.	−20° C.	−30° C.	−40° C.	−50° C.	−60° C.
Relative humidity	100	91	82	74	67	61	55

Condensation at Temperatures above the Freezing Point.

It was in 1880 that Aitken first showed that condensation does not necessarily take place in air when its temperature is lowered below the dew point. He expanded carefully filtered air and found that no fog formed even when there was considerable supersaturation. Aitken was led to the conclusion "that vapour molecules in the atmosphere do not combine with each other, that before condensation can take place there must be some solid or liquid nucleus on which the vapour molecules can combine, and that the dust in the atmosphere forms the nuclei on which the water-vapour molecules condense."

Aitken invented a most ingenious instrument, easy to work and very transportable, by means of which it is possible to count the number of nuclei present in the air. Thousands of tests of the atmospheric nuclei have been made with this instrument at many places over the world, and nowhere has air free from nuclei been found. The number of nuclei is seldom less than 100 per c.c., while in most country places the nuclei rise to thousands, and in cities such as London and Paris the number may be so great as 100,000 to 150,000 per c.c.

The general explanation of these observations is as

[1] Discourse delivered at the Royal Institution on Friday, March 2, 1923.

follows. If there were no dust particles present the drops of water would have to be built up from aggregates of water molecules. Now the radius of a water molecule is 2×10^{-8} cm., therefore if a few molecules met together by chance they would only form a very small drop, which would be so small that it could not exist unless there was large supersaturation. For example, according to Table II. a drop having a radius of $7 \cdot 2 \times 10^{-7}$ cm. would require a supersaturation of 20 per cent., yet nearly 20,000 water molecules would be required to form such a drop. If, however, there were dust particles present the molecules of water would be deposited on them, and the radii of the initial drops would be so large that little supersaturation would be required to maintain them.

This explanation appeared to satisfy every one for a long time, but in recent years considerable doubt has begun to be expressed. Already, in 1885, Assmann had searched for the dust nuclei when cloud particles evaporated under the microscope, and had come to the conclusion that if any were present they must have a smaller radius than $2 \cdot 5 \times 10^{-5}$ cm.

In 1912, Wigand made the reverse experiment. He first took careful counts of the number of nuclei in the air, then he created large quantities of dust by beating carpets, blowing up large clouds of coal, coke, and ordinary dust by means of bellows. Although he made such large clouds of dust that it was extremely unpleasant to work in them, he could not find any increase in the number of nuclei in his condensation apparatus.

In 1910, A. Wegener directed attention to another difficulty. The distance one can see through the atmosphere depends on the number of dust particles present and their size. From measurements made at Ben Nevis it had been found, from a comparison between the transparency of the atmosphere and the number of nuclei measured in Aitken's instrument, that the damper the air the less the number of nuclei necessary in order to see the same distance. The observations gave the following result:

TABLE III.

Depression of the Wet Bulb.	Number of Nuclei present in 1 c.c. with a Constant Distance of Vision.
1·1-2·2° C.	$1 \cdot 25 \times 10^4$
2·2-3·9	1·71
3·9-5·5	2·26

This can only be explained if the size of the dust particles increases as the humidity increases, even when the humidity is still far below its saturation value. But this is not an effect which one would expect if the only function of the dust particles is to act as nuclei, for there would be no condensation on them until the air has reached its saturation point. At all humidities less than 100 per cent. the dust particles would remain dry and therefore of constant size.

From these and other observations meteorologists have been led to the opinion that condensation does not commence on dust particles, if dust is to be understood in the ordinary way, but on hygroscopic substances, and that Aitken's instrument does not measure the number of dust particles present but the number of hygroscopic particles.

A great deal of work has recently been done on this question, especially by Köhler in Norway. Working on a mountain in the extreme north of Norway, Köhler analysed the water obtained from the large deposits of rime which formed on the surroundings of his observatory. Rime is frozen cloud particles, and in this way he was able to determine the chemical contents of the actual cloud particles before they had had time to become contaminated. He found that calcium chloride was always present, and concluded that sea-salt obtained from the spray of the sea forms the true nuclei of cloud condensation. His results indicate that when the drops are extremely small there is sufficient salt present to reduce the vapour pressure to the same extent as the small radius of the drop increases it, thus allowing condensation to take place. Köhler is tempted to generalise his results and to contend that sea-salt is the main foreign substance on which condensation takes place. It is, however, not necessary to go so far as this, for there are many other sources of hygroscopic substances. Lenard and Ramsaner have shown that sunlight—probably only the ultra-violet part—acts on the oxygen, nitrogen, and water vapour of the atmosphere, producing very hygroscopic substances.

Large quantities of material capable of becoming condensation nuclei are produced by all processes of combustion. Thus the household fires and factory chimneys of centres of industry produce vast quantities of nucleus-forming material, chief of which is sulphurous oxide, SO_2. This, when illuminated by sunlight in the atmosphere, is a very hygroscopic substance capable of causing condensation in unsaturated air. It is estimated that in England something like 5000 tons of sulphur are burnt each day in coal fires, giving enough sulphur products to pollute the atmosphere from Land's End to John o' Groat's. Other products of combustion are also hygroscopic; thus it is not surprising that air from large industrial centres contains enormous quantities of nuclei.

It is not necessary for hygroscopic particles to be large in order for water to be deposited upon them. Their chemical affinity for water is sufficiently large to counterbalance the surface tension forces which cause small pure-water particles to evaporate unless there is supersaturation. A single molecule of a hygroscopic substance would probably be able to gather around itself sufficient water to make a drop large enough to grow by ordinary condensation. Thus, whereas the hygroscopic properties are important to build up a drop to a certain size, after that size has once been reached the hygroscopic attraction may cease through excessive dilution, but condensation will continue until the drop is in equilibrium with the surrounding vapour.

The ordinary small ion, in my opinion, takes no part whatever in meteorological processes. Before any deposition of water can take place on small ions, four-fold supersaturation is necessary in the case of negative ions and six-fold in the case of positive ions. We have absolutely no evidence of anything like these supersaturations in the atmosphere, and I have shown at some length, in a paper published in the *Philosophical Magazine,* that even in the case of thunder-storms, in which the conditions are by far the most favourable for the formation of supersaturated air, small ions take no part in the condensation. Further, we have no evidence that small ions act like hygroscopic substances; they do not appear to grow appreciably in size in saturated air, in fact they act like any other air molecule until four-fold or six-fold supersaturation is actually reached.

With regard to large ions (Langevin ions), these do appear from Pollock's work to grow with increase of humidity; but, as Pollock found that they do not form in pure air, these ions are probably nothing more than ordinary hygroscopic nuclei, with a small ion attached.

Without detracting in any way from the value of Aitken's work, we see that it is necessary to revise his conclusions, and to say that hygroscopic substances and not dust form the nuclei of condensation. I do not think that Aitken would have been surprised at this development of his work, for he clearly recognised the importance of salt particles as efficient nuclei.

Condensation at Temperatures below the Freezing Point.

When the temperature of the air is below the freezing point, condensation of the contained water vapour is a still more difficult problem, for there is very little experimental evidence to go upon. One thing is certain: owing to the small amount of vapour present, it is inconceivable that condensation will take place by the fortuitous meeting of molecules; some kind of nuclei therefore will be necessary.

According to experiments made on crystallisation from supersaturated solutions, we may conclude that crystallisation does not start readily on a perfectly spherical surface. An angular nucleus is necessary, and the nearer the angles are to those of the natural angles of the crystal the more readily will condensation take place. When sledging in the Antarctic with Captain Scott in 1911 we became enveloped in a fog during sunshine. On the fog opposite the sun we saw a white bow in the position usually occupied by a rainbow. This phenomenon can only be explained on the assumption that the fog was composed of small spheres; but the temperature was – 29° C. (– 21° F.). We are quite familiar with super-cooled water drops which have been formed when liquid drops are cooled from temperatures above to temperatures below the freezing point. In this case there was no part of the atmosphere within hundreds of miles of the place of observation in which the temperature was above the freezing point, and almost a dead calm existed at the time; hence these drops could not have formed at a high temperature and then been super-cooled.

The only explanation which appears possible to me is that in the clear air of the Antarctic there are no "dust" particles suitable for condensation available, but there are plenty of the hygroscopic molecules of which we have already spoken. With increasing humidity these hygroscopic molecules attract water from the air and form clusters of water molecules; but we know from colloidal chemistry that such clusters are in the spheroidal and not in the crystalline form. If this explanation is correct we have real liquid drops and the vapour pressure in the air must be that appropriate to a water surface—we may neglect the curvature of the drops, as their radii were probably of the order of 0·001 cm. But according to Table II. air at – 30° C. is saturated with reference to ice at a relative humidity of 74 per cent., hence in this case the air was heavily supersaturated with reference to the solid state. This accounts for the fact, recorded at the time, that "the fur of the sleeping-bags and the wool of sweaters became covered with hoar frost," for these substances formed excellent nuclei for the condensation of the water vapour direct into the solid state.

Support for this explanation is given by observations made by Wegener in Greenland. He describes how, in temperatures below – 40° C. with perfectly clear air, a strip of fog started at the house and extended for several kilometres in the direction of the wind. At such temperatures condensation takes place on water at 100 per cent. relative humidity, but on ice or solid nuclei at 67 per cent. The actual humidity was between these limits, therefore the air was not saturated with reference to the hygroscopic nuclei, but was supersaturated with reference to solid nuclei. There were, however, none of the latter present in the pure free air, but the air escaping from the hut was highly charged with solid nuclei, chiefly the products of combustion, and when this contaminated air mixed with the pure air condensation took place and the long strip of mist resulted.

This observation furnishes the explanation of an old-standing difficulty in meteorological optics. Cirrus and other very high clouds frequently exhibit a most beautiful colour effect, which has received the name iridescent clouds, as the clouds appear to be iridescent with colours like those of mother-of-pearl. If cirrus clouds are always composed of ice particles, as one has generally concluded on account of the low temperature of the atmosphere where they form, the colours cannot be satisfactorily explained; but if they are composed of water drops the explanation is easy. If water drops can exist at $-30°$ C. near the earth's surface, there is no longer any reason to postulate ice crystals for the cirrus clouds; and we may now say definitely that iridescent clouds prove that cirrus clouds are sometimes composed of spherical water drops. But it also proves that air, especially in the upper atmosphere, is frequently devoid of solid nuclei on which condensation can take place.

Haze.—Perfectly pure air is almost completely transparent to visual light waves, and if the air were always pure we should see distant objects through air almost as clearly as through a vacuum. But the air is never pure; there are always more or less particles of foreign matter present. The action of these particles is two-fold: first, they reduce the amount of light reaching the eye from distant objects; and, secondly, in the day-time they scatter the general light of the sky and so send to the eye extraneous light which reduces the contrast between distant light and dark objects on which visibility depends. Generally this foreign matter consists of a mixture of solid ponderable particles and hygroscopic molecules. The latter in perfectly dry air would be practically invisible, but when loaded with water in a humid atmosphere they add to the obscurity of the atmosphere.

The amount of obscurity will therefore vary with the amount of solid matter and with the humidity of the air. Haze is due to this kind of obscurity, and varies in intensity from the slight obscurity of polar regions, which depends almost entirely on the hygroscopic particles, to the dense obscurity of a dust storm in tropical regions, which is due almost entirely to solid particles.

Mist.—When the temperature of air falls, the humidity increases until the saturation point is reached. The diameters of the hygroscopic particles grow, but even in saturated air the amount of water extracted is not great, and if there is little solid matter present the obscurity is not marked. But if the temperature falls below the dew point the hygroscopic particles are sufficiently large to form excellent nuclei for condensation, and relatively large amounts of water are deposited for small falls of temperature.

Real condensation has now commenced, and the obscurity changes from that of haze to that of mist. It has been a common practice to record atmospheric obscurity as haze when there is a noticeable difference between the readings of the wet- and dry-bulb thermometers, and as mist when the readings are the same. This, however, is not a true criterion, for the air can be saturated without condensation, while mist cannot be formed until water has been condensed on account of a fall of temperature after the dew point has been reached. The whole process of the formation of haze and mist is continuous, and in practice it is practically impossible to say when haze becomes mist, although extreme cases are easily distinguished. Nevertheless haze and mist are fundamentally different, for haze owes its origin to foreign matter, and the small amount of water associated with hygroscopic nuclei, while mist is due to an actual precipitation of water from vapour to liquid.

Fog.—There is, however, no fundamental difference between mist and fog: in most cases fog is only a dense mist, and the density at which mist becomes fog is a matter of definition. It is now the practice of the London Meteorological Office to limit fog to the obscurity in which objects at one kilometre are not visible.

When mist and fog are formed in fairly clear air they are white. On the other hand, if the air contains a large quantity of impurities, such as carbon particles from imperfect combustion, the mist particles absorb the impurities and become themselves dark-coloured. In this way are formed those dense fogs in London which are likened to pea soup. It was originally thought that the density of a London fog was due to the fact that the smoke of the city provided an unusually large number of nuclei on which condensation could take place, thus offering a temptation to the air to deposit its moisture which it could not resist. As a matter of fact, there are always sufficient nuclei in the purest air in England to allow of the formation of fog whenever the meteorological conditions are suitable. The relationship between smoke and fog is peculiar, and may be said to be accidental. The meteorological conditions which are necessary for the formation of fog are such that while they last smoke cannot get away either vertically or horizontally from the place of its origin. Above the fog there is a temperature inversion which effectively prevents all upward motion of either air or smoke, while fogs over the land usually form in calm air. Thus during a fog practically all the smoke which London makes is kept over it and within a few hundred feet of the ground. This smoke, combined with the deposited water, can, as we all know, produce such an obscurity that midday is as dark as midnight. The total abolition of smoke from London would not reduce the occasions on which mist and fog occur, but many fogs would remain mists, and we should never have a "London particular."

For the formation of mist and fog it is necessary that the temperature of the air should continue to fall after the dew point of the air has been reached. The extent of the fall below the original dew point determines the density of the obscurity, neglecting for the moment the effect of impurities. This cooling can be brought about in several ways, of which only two are of real importance. Fogs may be caused by warm air blowing over a cold sea or a cold land surface, and the method by which the temperature of the air is then reduced on account of turbulence was first explained in a brilliant paper by G. I. Taylor, which has become a meteorological classic. The fogs of London are, however, almost entirely due to the loss of heat from the lower layers of the atmosphere into a clear sky above. The air radiates its heat, its temperature falls, and condensation takes place as already described. Other methods of fog formation, such as the mixing of warm and cold air, are of secondary importance and never give rise to more than patchy local mists or light fogs.

Clouds.—Adiabatic cooling plays no part in the formation of mists and fogs, because the pressure changes in any given layer of the atmosphere are relatively small and slow. Appreciable adiabatic cooling can take place only when air is raised in the atmosphere, and then the cooling may be large and rapid.

When air not saturated rises in the atmosphere its temperature is reduced by about 1° C. for every 100 metres of ascent. When the ascent is carried far enough the dew point is reached, after which any further rise will cause condensation on the nuclei present. As the ascent is carried beyond the point of condensation more and more water is deposited, with a consequent increase in the size of the drops. This is the manner in which clouds are formed, and there are very good reasons for saying that it is the only way. Thus there is a fundamental difference between the method of formation of clouds and fogs: fogs form without any ascent of the air, while clouds are never formed without it. Thus it is not correct to describe clouds as fogs of the upper atmosphere.

The very sharp line of demarcation between the air under a cloud and the cloud itself needs explanation. There is no slow transition between the clear air and the cloudy air, as one would expect if clouds were due to the gradual increase in the size of drops from small nuclei to relatively large cloud particles. We must picture the hygroscopic nuclei collecting more and more water around them as they rise with the ascending current, owing to the increase in relative humidity. But when saturation is reached they are still very small, say about $1{\cdot}1 \times 10^{-5}$ cm., that is, they are smaller than the wave lengths of light (5×10^{-5} cm.), and therefore cannot be directly observed, and produce little obscurity in the air, which still appears relatively clear. Drops of this size need supersaturation to grow, but we see from Table I. that only 1 per cent. supersaturation is necessary. They are, however, unstable, for as they grow they need less supersaturation. Thus as soon as the air is sufficiently supersaturated to be in equilibrium with the nuclei the slightest further rise causes the drops to grow very rapidly to the size in which they are in equilibrium with saturated air. The height at which this change occurs is the height of the base of the cloud.

Rain.—Before we are able to form a clear idea of the processes which give rise to rainfall it will be necessary to consider the laws of the fall of water drops through the air.

It is well known that in a vacuum all bodies fall at the same rate with a constant acceleration, so that their velocity constantly increases. When, however, bodies fall through a resisting medium, such as air, they more or less quickly reach such a velocity that the resistance of the air equals the pull of gravity, after which they fall with a constant velocity, which is different according to the density and shape of the falling bodies.

Experiments have been made to determine the rate of fall of water drops through air at atmospheric pressure, and the following "end velocities" have been found.

TABLE IV.

Radius, cm.	Velocity calculated by Stokes, cm./sec.	Velocity observed by Schmidt, cm./sec.	Velocity observed by Lenard, cm./sec.
0·0005	0·3	..	..
0·001	1·3	..	..
0·005	32	..	..
0·010	126	..	..
0·020	..	180	..
0·030	..	270	..
0·040	..	340	..
0·050	..	393	440
0·100	..	577	590
0·150	..	692	690
0·175	..	740	737
0·225	..	..	805
0·273	..	..	798
0·318	..	..	780

Three important points are to be noticed about these results.

(*a*) The extremely small velocities with which small drops fall. The average radius of the drops in clouds from which rain is not falling is approximately 0·001 cm. Such particles, according to our table, would fall only at the rate of a little over a centimetre a second.

(*b*) As the drops get larger the rate of fall tends to a constant value of about 8 metres a second.

(*c*) Drops for which $r = 0·25$ cm. have the most rapid fall, larger drops fall more slowly.

Lenard has given the reason for (*c*). He showed that the friction on the air causes deformation of the drops, so that instead of retaining the shape of spheres they become flattened out, thus presenting an increased resistance to the air through which they are falling. This deformation becomes appreciable when the radius of a drop is about 0·2 cm. and then increases rapidly as the drop grows larger. When the radius is about 0·25 cm. and the drop is falling at the rate of 8 metres a second, any further increase in volume produces a greater flattening, and instead of the velocity being increased it is slightly decreased. When the size of the drop is such that if it were not flattened it would have a diameter of about half a centimetre, $r = 0·25$ cm., the drop becomes very unstable, and all drops larger than this quickly break up into a number of smaller drops, which of course fall more slowly. This means that raindrops can never fall through air at a greater velocity than 8 metres a second. Small drops fall slower than this, and large drops flatten out as soon as they are falling at 8 metres a second, and then soon break up into smaller drops.

In the above all the velocities have been given for air at normal pressure. If, however, the pressure is less, all the results are the same, except that the velocities must be increased in the proportion $\sqrt{B}/\sqrt{P}$, in which B is the normal pressure and P the actual pressure.

Dines has found that in Europe the quantity of vapour in air is always very small. If the whole water vapour in the atmosphere on an average summer day were precipitated it would only give a total rainfall of 0·80 in. The greatest amount ever measured on a summer day in Europe would only give 1·5 in. of rain, and of course the quantity is much less in winter. How then can we have rainfall of several inches of rain in the course of an hour or so? The answer is simple: the ascending currents which are necessary to cause precipitation carry with them their own water vapour to supply the rainfall. An ascending current of air which is saturated at 10° C. (50° F.) needs only an upward velocity of 1 metre a second to carry with it sufficient vapour to give a rainfall of more than 1 inch per hour, so that there is no difficulty in explaining the greatest rate of rainfall ever experienced in the tropics.

There are many ways in which the air is caused to rise in the atmosphere; ascending currents up to many metres a second are possible, and do occur in the atmosphere. Let us think of air rising at about 10 cm. per second, which is the order of the upward velocity of the air in depressions. At a certain height cloud particles form as already described. These have a radius of about 0·001 cm. and fall relatively to the air at 1·3 cm. per sec., hence they are carried upwards with the air, but the base of the cloud remains at the same height because new cloud particles are constantly being formed at that height. As the air rises the cloud particles grow in size, because water is being condensed on them, and they lag more and more behind the air. Drops with a radius of 0·002 cm. are falling as rapidly as the air is rising, and therefore remain stationary, while drops of 0·007 cm. are falling at the rate of one metre a second, and therefore fall through the rising air and appear at the earth's surface as rain. It is obvious that this process will continue as long as the ascending currents continue, and in this way we get the continuous steady rain with which we are so familiar in this country.

The rate of rainfall will increase as the upward velocity of the ascending air increases until the upward velocity becomes greater than 8 metres a second. When this occurs no water can fall through the ascending air for the reason already explained. All water condensed in such an upward current—and it will be a very large amount—is carried upwards until the upward air velocity falls below 8 metres a second, as it is bound to do at some height owing to lateral spreading out. Here water accumulates in large amounts. It is the sudden cessation of the upward velocity in such an ascending current which gives rise to the so-called cloud-bursts, for when the sustaining current stops the accumulated water falls just as though the cloud had literally burst.

The accumulated water while it is suspended in the air is constantly going through the process of coalescing into large drops, which at once become deformed and broken up again into small drops. Every time a drop breaks there is a separation of electricity, and this is probably the chief source of electricity in a thunderstorm. This explains why thunder-storms are associated with heavy rainfall and do not occur in polar regions where there is no rain.

Hail.—I have already explained how the small liquid cloud particles are carried upwards with the ascending air, but as the air rises its temperature constantly falls, and there must come a point in the ascent when the temperature falls below the freezing point. The cloud particles do not immediately turn into ice. As a matter of fact it is not an easy matter to freeze perfectly pure water, and water can remain liquid at temperatures far below the freezing point. Observations made on mountains and in balloons and aeroplanes have proved conclusively that cloud particles remain liquid at temperatures so low as $-20°$ C. How far small drops can be super-cooled before they solidify we do not know, but super-cooled drops are in a very unstable state. From Table II. we see that at $-20°$ C.

ice forms when the relative humidity over water is 82 per cent., which means that if water and ice are simultaneously present the relative humidity of the air relative to the ice is 121 per cent., *i.e.* it is 21 per cent. supersaturated. Thus if a few drops become converted into ice they are in a highly supersaturated atmosphere, and so will grow rapidly at the expense of the water drops. Meteorologists generally consider that $-20°$ C. is about the limit at which large water particles can exist without changing into ice.

Let us consider a region in the atmosphere through which there is an ascending current of air. The air is supposed to have a temperature of 20° C., and a relative humidity of about 50 per cent. at the ground. As the air rises, at first its temperature is reduced by 1° C. for each 100 metres of ascent. Hence by the time it has risen 1000 metres its temperature will have been reduced to 10° C., and it will have reached its dew point. Here the cloud level begins. As it rises still further its temperature continues to decrease, but not so rapidly as before, because the condensation of water vapour releases the latent heat of vaporisation. It reaches 0° C. at a height of 3000 metres. Hence the region between 1000 and 3000 metres contains only drops of water. As the air rises above 3000 metres the temperature falls still lower, but the water particles do not freeze at once, they remain super-cooled. We may assume that at $-20°$ C., which is reached at about 6000 metres, the super-cooled drops solidify and the remaining part of the cloud above this level is composed of snow alone.

There will not be a sharp division between the region of super-cooled water and the region of snow. For a certain distance ice crystals and super-cooled water will be mixed together. Such conditions are very unstable, and from considerations of the vapour pressure alone the ice particles grow rapidly, because the vapour over super-cooled water is highly supersaturated with respect to ice. In addition, the slightest contact between ice and super-cooled water causes the latter to solidify at once. The original ice particle will therefore quickly grow in size and, if the ascending current is not too large, will commence to fall. It has, however, to fall through 3000 metres of super-cooled water drops, and in doing so grows appreciably in size. As each super-cooled water particle strikes the ice it solidifies, and also imprisons a certain amount of air, so that by the time the ice particle reaches the bottom of the super-cooled region it is simply a ball of soft white ice without any sign of regular crystalline structure.

If the descent through the super-cooled region has been fairly rapid the temperature of the ice ball will be considerably below the freezing point when it arrives in the region where the temperature is 0° C., and the cloud particles are not super-cooled. As it continues its way downwards it receives a considerable addition of water: in the first place, by direct deposition, because it is colder than the air; and, secondly, by collision with the water particles. This water covers the surface of the cold ice ball with a uniform layer of liquid which quickly freezes into clear solid ice, with little or no imprisoned air. Finally the ice escapes from the bottom of the cloud, and falls to the ground as a hailstone.

When hailstones are split open to show their internal structure we can nearly always see the inner soft white mass of ice which was collected while the stones were in the super-cooled region, surrounded by a layer of clear transparent ice formed by the freezing of the water deposited when the stone was passing through the non-super-cooled region.

This simple explanation of the formation of a hailstone was not considered satisfactory at first, because it was considered that hailstones produced in this way must necessarily be small. Trabert calculated that if a hailstone started to fall from a height of 2 kilometres, and swept up all the water it met on its way down, its radius would grow only by 2 millimetres. But Trabert left many things out of consideration, as pointed out by Wegener. In the first place, he started his hailstone much too low in the atmosphere; he should have started it from a height nearer 8 kilometres than 2. Secondly, he neglected the effect of the ascending currents. We know that there are violent ascending currents during thunder-storms, in which alone hailstones are formed. The ascending currents may be so violent that even large hailstones will not be able to fall through them, but they are all the time falling rapidly relatively to the air, and therefore sweeping water out of it.

The velocity with which a hailstone falls through still air at atmospheric pressure is

$$v = 1246\sqrt{r} \text{ cm./sec.}$$

If, therefore, the velocity of the ascending current were 10 metres per second, the hailstone could not commence to fall until it had a radius of 0·64 cm. It would then commence to fall very slowly as its size grew larger, but it would all the time be moving relatively to the air at a greater rate than 10 metres a second. Thus the effective height through which it would fall would be very great in comparison with the actual height.

It must also be remembered that with such an ascending current no water could fall in the form of rain; all the water would be retained in the cloud, the water content of which could be very large indeed, thus giving large quantities of water to be swept up by the hailstone. When we also take into account that a hailstone is generally very much colder than the surrounding saturated air, so that the deposition of moisture on it from the vapour would be large, there is no difficulty in explaining the size of all ordinary hailstones.

It must not be considered, however, that an ascending current is steady. Just as we have gusts and lulls in horizontal winds, so we have increases and decreases in the velocity of ascending currents. Thus a hailstone which has penetrated into the lower part of the cloud might be blown upwards and so go through the whole process again. In this case we should have a layer of white ice deposited around the clear layer, around which again there would be another layer of clear ice. In fact, if a hailstone is held by the ascending currents near to the region where the temperature is 0° C., it might well be carried up and down between the regions where the water is super-cooled and where it is not several times. We should then have several concentric layers of clear and white ice, and a broken stone would have the appearance of an onion. Such cases are not at all uncommon.

For the formation of hailstones two conditions must be fulfilled.

(*a*) The clouds must extend through a great vertical height so that the three regions of water particles, super-cooled particles, and snow are extensive and well developed.

(*b*) There must be violent ascending currents, otherwise the stones would fall too rapidly to grow to a large size.

These conditions are best fulfilled in warm regions, for there violent ascending currents are most easily developed, and the condensation starts at a relatively high temperature, so giving regions of water particles and super-cooled water particles of great depth. These are the reasons why hailstones only occur during the summer in temperate regions, and why the most violent hailstorms and the largest hailstones are found in tropical regions.

Soft Hail.—If the temperature at the ground were much lower than in the case just considered, the region between the bottom of the cloud layer and the zero isothermal would be much reduced. It is in this region that the hailstone receives its coat of clear transparent ice. The hailstones which then fall would be relatively small, and consist only of the soft white balls appearing in the centre of the more complete hailstones.

Falls of soft hail of this nature are quite common in the winter in Europe and in the hills of India; there are frequently falls of soft hail during the winter and spring in Simla. The reason is clear, for in Europe the temperature of the ascending current is so low that the freezing point is reached almost at the bottom of the cloud, while in Simla the clouds form over the plains, and Simla itself is so high that the region in which water particles exist is mainly below the station. Thus the hail which falls in Europe during the winter and in the hills of India falls almost immediately out of the region of super-cooled water particles, and therefore has had no opportunity for building up a layer of transparent ice.

The form of these soft hailstones is most instructive. In most cases they are like cones with a hemispherical base. It is clear from this form that as they have fallen through the super-cooled region they have struck the water particles on their under sides. This has caused the bases to grow, and the cone above is really the shape of the stream-lines behind the enlarged base. A stone which has once commenced to have this form will retain it throughout, for the cone acts as a kind of tail and tends to keep the base always at right angles to the relative air motion.

Snow.—Snow which forms over an ascending air current in which water particles first form will probably have solidified cloud particles for nuclei. Whatever the nuclei may be, as soon as the initial crystals are formed further condensation takes place exactly as in the precipitation of water, but the vapour condenses directly into the solid state without first going through the liquid state. The crystals of water are hexagonal prisms, and water in the crystalline state in the atmosphere shows all the wonderful shapes that this form of crystallisation can take. Having once started, the crystals may grow either along their central axis, giving rise to long thin prisms, or along their six axes to form hexagonal plates.

Sometimes the growth is uniform, so that the result is a perfect hexagonal plate, at others the growth along the axes is more rapid than in the space between; this gives rise to stars, having a beautiful feathery appearance. The actual crystals vary in size, from minute crystals which can scarcely be seen by the naked eye to plates a quarter of an inch in diameter. In cold regions the crystals are small, because there is little water vapour present from which they can grow. In the Antarctic during the winter, when the temperature was always near or below 0° F., only the smallest crystals were seen, so small that they were almost like dust.

When crystals form at temperatures near the freezing point they grow to their largest size. When the air is full of large crystals frequent collisions take place. The crystals become interlocked and bundles of many separate crystals are formed; these produce the ordinary snowflakes which, on account of their size and weight, fall relatively rapidly. It is to these latter that the term snow should be applied. With this restriction, snow occurs only when the temperature is near the freezing point.