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Spiritual Healing.

IN accordance with a resolution of the Lambeth Conference, 1920, the Archbishop of Canterbury appointed a committee to consider and report upon "the use with prayer of the Laying on of Hands, of the Unction of the Sick, and other spiritual means of healing." Sir Clifford Allbutt, Sir Robert Armstrong-Jones, Dr. William Brown, Dr. Hadfield, Dr. W. H. R. Rivers, and Dr. Jane Walker were appointed to serve with fifteen other members, of whom seven were bishops. The committee's report, signed by all the members, save Dr. Rivers, who died in June 1922, has now been made public. Its purely scientific interest is negligible, but it is nevertheless assured of a wide public among scientific and medical readers by the interest attaching to its conclusions and suggestions.

The modern scientific attitude towards disease has been developed by successive stages of positive assertion, and any denial which it entails is accidental. Sick people are no longer held to be bewitched or possessed of devils, because modern ætiology has more serviceable notions to guide it; and what is true concerning the causation of disease is true also of cure. The virtues of charms, amulets, and incantations have been discredited by the development of a superior therapy.

The various psychotherapeutical techniques which have been elaborated of late, and the associated revival of scientific interest in the mental functions of human beings, have their counterpart in an unprecedented growth of faith-healing sects and, in the Church of England, in a revival of "systems of healing based on the redemptive work of our Lord." Some action by ecclesiastical authority seems to have been inevitable. The absurdest claims were put forward by extremists within the Church, while "views subversive of both moral and religious principles" appealed as vigorously to popular interest from outside. The Archbishop's committee appears to have done its work fearlessly and well. If it has set aside or failed to solve problems of the greatest magnitude and importance from a scientific point of view, it has at the same time set its face sternly against much that is pernicious and false in current movements; it has offered every discouragement, both by argument and by rebuke, to those who advance extreme claims; and it has produced a statement which is moderate, coherent, and, for the most part, intelligible. No evidence was found "of any cases of healing which could not be paralleled by similar cures wrought by psychotherapy without religion, and by instances of spontaneous healing, which often occurred even in the gravest cases in ordinary medical practice." The inclusion of such an admission in the text of the report suggests that the

authors would shrink from advancing a supernatural explanation for such cures as they deem "spiritual" healing to have achieved.

No specific claim to cure is made on behalf of "spiritual" healing: indeed, the report is directed so strongly against all physical interpretations of such healing that specificity would be out of place. For "spiritual" healing is defined as all or any curative means pursued "in reliance upon God." The whole argument proceeding therefrom appears to be governed by deference to scientific views and a desire to state the case in conformity with them. No cases were found in which those practising "spiritual" healing "did not desire to work with the medical profession." But the chief, indeed, the only reason advanced for such a co-operation appears to be that thereby not only is disease alleviated, but also the whole nature of the patient is raised to a higher level. So far as the report goes, no definite claim is made for the efficacy of "spiritual" healing in any but a spiritual sense. It is explicitly laid down that no sick person must look to the clergyman to do what it is the physician's or surgeon's duty to do. In "spiritual" healing, the healing of the spirit is primary; and in the light of such a statement it may be agreed that "religious methods are applicable to all cases of sickness."

The reader of the report must seek in vain for any indication concerning the real attitude of the committee to the very definite question it was appointed to consider. Having laid it down that the Church must sanction methods of religious treatment of bodily disease, "but in doing so must give full weight to the scientific discoveries of those who are investigating the interrelation of spirit, mind, and body," the committee suggests, as a mode of treatment "more immediately directed to the complete restoration of the patient," the use of Unction, "*i.e.* anointing with oil by a priest or of the Laying on of Hands (either by a priest or a lay person) or of both."

From this recommendation both Sir Clifford Allbutt and Sir Robert Armstrong-Jones dissociate themselves. It is difficult to harmonise the proposal with the rest of the report without supposing that the committee regarded the suggested ritual from a purely psychotherapeutical point of view. That the doctors could not persuade themselves to do likewise argues a refinement of intellectual principle which does credit both to science and to themselves; for in the popular mind Unction, however effective, and the more so the more effective it may be in certain cases, must inevitably stand in much closer relation to magic and superstition than to a rational therapeutics and enlightenment. Herein lies the main interest of the report for science.

Speculative Bio-Sociology.

Die soziologische Abstammungslehre. Von Dr. Hermann Schulte-Vaerting. Pp. 136. (Leipzig: Georg Thieme, 1923.) 1*s.* 9*d.*

THE author of this work thinks that animal-societies have played an important part in the evolution of species. They occur, as is well known, in various forms. Among insects the oldest phylogenetically is that of the termites, where the non-breeders or neuter workers are of both sexes. Among bees the workers are arrested females, who may be, however, occasionally reproductive. The queens and the drones do no work. Among ants the arrested females or workers are occasionally reproductive; the males do no work; the queens may do some.

In mankind the workers are the men, who are at the same time reproductive; the non-workers (the women!) are recognised as representing "the reproductive principle," and are restricted in their activities outside that sphere. Thus the Chinese ladies have their feet compressed, for this keeps them from moving about too much.

To many biologists it seems difficult to arrange human society in line with the communities of ants, bees, and termites, but Dr. Schulte-Vaerting is more impressed by the resemblances than by the differences. He sees among the social insects a consummation of tendencies, some of which are not more than incipient in mankind, such as the evolution of a non-reproductive worker caste, a communal ownership of property, and State education of children. He does not suggest that man should take the ant as a model; but rather, if we understand him aright, that man should see in ants a warning of what may be in store for him unless evolutionary changes at present incipient are counteracted by others. We incline to think that the analogy between the ant-hill and human society is too remote to be taken very seriously, but this is not the author's view. We must admit that his position is in some measure strengthened by what is argued for in Prof. W. M. Wheeler's recent lectures on "Social Life among Insects." For this great authority declares that: "Human and insect societies are so similar that it is difficult to detect really fundamental biological differences between them." We wonder.

The central idea of Dr. Schulte-Vaerting's book is upsetting, and we do not understand how the author can seriously entertain it. What it comes to is briefly this. When an animal-state is formed, say by a prolific stock under pressure of competition with rival stocks, differentiation sets in. Those variations persist that are well suited to the conditions of social life. Thus there are, Prof. Wheeler tells us, sixteen

different kinds of individuals among termites. One outstanding dichotomy is that between breeders and neuters, which secures economy by division of labour. There are other justifications of the dichotomy, but it is not necessary to go into that. The present point is that polymorphism arises, and this is the key or a key to the origin of new species. For the most successful societies are apt to disintegrate; their perfection of division of labour may be their undoing. Now when a society dissolves there may arise a variety of non-social species, corresponding to castes in the previously existing society, always presupposing that the castes have not lost the power of reproducing their kind. What usually happens when a community hypothetically dissolves is that the neuters die out. The perfect insect in the non-social species corresponds to the queen, and the larval stages correspond to the workers of the pre-existent state! This, if we understand the book aright, is the topsy-turvy theory we are asked to consider. The students of bees and wasps assure us that the social species have evolved from solitary ancestors; here is another aspect of the case that societies may have broken up into solitary species. The cockchafer was the queen of some obsolete community of grubs, and the butterfly of a vanished caterpillar kingdom. Some day the Termite State will break up and the queen will be represented by the adult insect, with the workers and soldiers as her larvæ—but no longer repressed.

What evidences are there of all this? The author says they are furnished by the recapitulation that goes on in the individual development. As stage succeeds stage we find traces of ancestral life in a dimorphic or polymorphic society. At least we should find them. As a striking example attention is directed to the fact, which does not seem to us much of a puzzle, that lungs appear in the mammalian embryo before the teeth, though these are phyletically older. This is regarded as decisive evidence, for it is interpreted as a recapitulation of the dwindling of masticating organs in the queens of bygone days!

A race of animals may have passed through more than one social phase. Thus a colony of Protozoa is the outcome of one state-forming process; zoophytes and tapeworms have two great events behind them; mammals and birds have three. That bladderworms represent the workers of a previous social state must be evident to all. We must confess that it seems to us like playing with a serious subject.

The book is full of surprises. Thus in connexion with termites, the author flies the kite of a third sex, which may be evolved in the course of millions of years. He suggests that polymorphism may go so far that the production of offspring by the female will require the joint efforts of two males.

We should like to give a glimpse of what Dr. Schulte-Vaerting discerns in human society to-day. He starts from a man-made society, in which man ruled and also worked. But the dominion of man is nowadays waning; he is falling into a minority; women are also becoming workers. Mankind is approaching the termitary in having "workers" of both sexes. It may be noted that human workers with head and with hand tend to approach the termites in another way—by becoming non-reproductive. But as women come to outnumber men more and more, they will become increasingly the governing sex. But the governing sex always seeks to keep the other sex in the minority. If men are dominant, then female infants are got rid of; if women are dominant they expose the male children. When a modern father, not too highly sophisticated, welcomes a son more enthusiastically than a daughter, he is subconsciously welcoming an ally. That is one more on my side, he says. In civilised communities it is not customary to expose infants, but the same adjustment of numbers will be effected, as Dr. Schulte-Vaerting points out, by methods of sex-control now on the horizon. So there will set in a gynarchy of wise women, with a large working-class of non-reproductive spinsters, and a carefully selected caste of fathers. We hope this is not really bio-sociology, for it is very wild.

J. ARTHUR THOMSON.

Lead Mining in Northumberland and Durham.

Memoirs of the Geological Survey: Special Reports on the Mineral Resources of Great Britain. Vol. 25: Lead and Zinc Ores of Northumberland and Alston Moor. By Dr. Stanley Smith, with Contributions by R. G. Carruthers. Pp. iv+110+15 plates. 3*s.* 6*d.* net. Vol. 26: Lead and Zinc Ores of Durham, Yorkshire, and Derbyshire, with Notes on the Isle of Man. By R. G. Carruthers and Sir Aubrey Strahan. Pp. iv+114+2 plates. 3*s.* net. (Southampton: Ordnance Survey Office; London: E. Stanford, Ltd., 1923.)

THESE two volumes complete the series of these Memoirs of the Geological Survey, devoted specially to lead and zinc mining in Britain; there are thus altogether eight of these memoirs on this particular subject, and unfortunately they record the existence of barely as many payable mines. This unfortunate fact constitutes, however, a remarkably good reason why the Geological Survey should collect and publish all available information while a fair proportion of the mining ground is still open and accessible, for it would otherwise probably be lost altogether. It is only by the collection of data such as these that it is possible to

make any progress at all with the relatively new branch of geology which is often referred to as mining geology.

The earliest geologists, the founders of the science, were the miners, but their work was necessarily largely empirical at the outset. When palæontology came to the assistance of geology, the latter was placed upon a more purely scientific basis, and there arose a school of geologists who prided themselves upon their devotion to abstract science and affected to despise its economic applications. Of late years, however, geologists have again turned their attention to the economic problems of geology, and, in particular, the study of ore deposition, at one time entirely neglected in Great Britain, is receiving close attention.

The two volumes before us are a valuable contribution to this study; it is perhaps unfortunate that they have been published as two volumes, and even so, the division might have been better made. County boundaries are of but little avail in discussing mineral deposits, especially when the counties of Northumberland and Durham are in question, for there are numerous important veins that have the audacity to disregard the boundary line and to pass from one county to another. Some confusion is bound to result, but the authors have wisely ignored to some extent the strict country boundaries. This method, though the more useful to the geologist, leads to some difficulties, which might perhaps have been avoided by indexing the two volumes together, or supplying ample cross references. For example, Henry's vein, a well-known vein worked with the Allenheads group, is described in the volume for Northumberland, and is not mentioned in volume xxvi., although it lies wholly in the county of Durham.

The general geology of all the districts dealt with is similar in that all the ore deposits occur in the Carboniferous Limestone; the facies of this formation varies, as is well known, in the different districts, the limestones in particular thickening greatly as the formation is followed southwards. Throughout both volumes stress is laid on the undoubted fact that the great majority of these lead veins show impoverishment in depth, though depth should perhaps be taken in a strict stratigraphical sense rather than in reference to surface contours, as the memoirs appear to imply. Thus in Weardale the Great Limestone appears to carry good lead ore at the greatest depth to which it has so far been followed, while the sills below the limestone are barren even at shallow depths below the surface, and in the Pateley Bridge area, in one of the few places where the deep-lying portions of the limestone have been tried, lead ore has been met with. In general terms, however, there is only too much reason to fear that the statement is correct and that all the districts here described are within measurable distance of exhaustion. Perhaps the only chance of any resuscitation in the Northumberland-Durham area would be by a trial in the Melmerby Scar Limestone, a deep-lying sill that has never been proved in the lead-producing districts; there is perhaps not much hope of success, but it may be argued that even a slender hope is better than none.

Mr. Carruthers contributes an interesting little account of the history of lead mining to volume xxv.; he seems to incline to the belief that the Romans worked lead on Weardale or Alston Moor, but there is no evidence at all to warrant this assumption. The Romans certainly penetrated into these remote districts, and the discovery of a Roman altar dating from about A.D. 240 at Eastgate is well known, but this does not prove that they worked or even knew of the lead ore. They were smelting lead in the Mendip Hills in A.D. 49, only six years after their occupation of Britain, and we have the evidence of Pliny, some quarter of a century later, that they were then getting from Britain more lead than they required. It is possible that lead was worked in Durham or Northumberland in Saxon times, but even of this there is no direct proof. The lead, which, according to the Venerable Bede, was used for covering the church at Lindisfarne in A.D. 680, may have come from local sources, or it may have been brought from the Yorkshire mines, which we know were worked in Roman times. The first direct evidence of lead mining in Durham is the grant by Stephen of the "minariam de Weredala" to Bishop Pudsey, which proves that at this date the mines had been opened and were well recognised.

It will be seen that these two volumes contain much interesting matter and contribute data that will be of use in discussing some of the vexed questions upon the deposition of lead ores, which appear to be as far off a final solution as ever. The authors have done their work well, in a thorough painstaking fashion, and have collected a mass of information of great value to all students of this fascinating subject. H. LOUIS.

The Theory of Numbers.

History of the Theory of Numbers. By Prof. Leonard Eugene Dickson. Vol. 3: Quadratic and Higher Forms. With a Chapter on the Class Number by G. H. Cresse. (Publication No. 256.) Pp. v+313. (Washington: Carnegie Institution, 1923.) 3.25 dollars.

THE third and concluding volume of Prof. Dickson's great work deals first with the arithmetical theory of binary quadratic forms. A long chapter on the class-number is contributed by Mr. G. H.

Cresse. Next comes an account of existing knowledge on quadratic forms in three or more variables, followed by chapters on cubic forms, Hermitian and bilinear forms, and modular invariants and covariants.

Like its predecessors, the present volume gives reports of the investigations made by various writers within the field of its subject-matter, and the author has made every effort to ensure a complete list of references. The volume is mainly concerned with general theories rather than special problems and special theorems. The investigations on which reports are made deal with some of the most advanced parts of the theory of numbers. Such a large number of the important papers are so recent that all previous reports and treatises are entirely out-of-date.

In the first two volumes the introductory pages gave a clear account of the leading results on the subjects treated. This was possible partly on account of the elementary nature of most of those subjects and partly because the gist of the investigations could be embodied in definite theorems expressed without the use of technical terms. In the last volume, however, it is a question, not primarily of explicit results, but chiefly of general methods of attacking whole classes of problems, the methods being often intricate and involving extensive technical terminology. To each of the longer chapters is prefixed an appropriate introduction and summary.

The only serious defect in the work is an inevitable one. In his resolve to record faithfully the work of every writer on the subject, the author often fails to point out which papers are the vital ones. Frequently it happens that some new idea introduced into a subject makes obsolete much previous work thereon: but there have been numerous instances where years have elapsed before the scientific world has grasped the significance of the new idea, and where researchers have expended much labour on lines that ought to have been abandoned. But to ask the author of so comprehensive a work to assess the relative importance of the papers as well as to record their contents would be expecting more of him than is humanly possible.

The most noteworthy omission from the work is an account of Dedekind's theory of algebraic numbers, a subject on which much fruitful research has been done in the last forty years. Prof. Hilbert's report of 1897 is now out-of-date, and it is to be hoped that a further volume of the history dealing with this branch of the subject will be compiled.

Prof. Dickson's great work will remain for many years the standard encyclopædia on the theory of numbers. Those in search of information on almost any branch of the subject are fortunate in being able to refer to so comprehensive a book of reference. It is to be hoped that the Carnegie Institution will arrange for the publication of supplementary volumes at intervals to keep the work up-to-date. Only one other branch of pure mathematics known to the writer has been similarly treated—in Sir Thomas Muir's "History of the Theory of Determinants."

Ventilation.

Ventilation. Report of the New York State Commission on Ventilation, appointed by the Governor of the State of New York at the Request of the New York Association for Improving the Condition of the Poor, and Supported by the Milbank Memorial Fund established and endowed by Mrs. Elizabeth Milbank Anderson. Pp. xxviii+620. (New York: E. P. Dutton and Co., 1923.) 15 dollars.

SOME years ago an investigation into the subject of ventilation was started by a former governor of the State of New York. The work of many years' duration of the commission appointed was rendered possible by the beneficence of Mrs. E. M. Anderson, who had been impressed with the fact that poor ventilation was general in public buildings and especially in public schools. The chairman of the commission was Prof. C. E. A. Winslow, professor of public health at Yale, with whom were associated experts in engineering, medicine, chemistry, and educational psychology respectively. The result is a handsome quarto volume of 620 pages, admirably illustrated by diagrams and curves; and with a complete statement of experimental data on which conclusions have been based, there is given an exhaustive account of every aspect of the problem of ventilation.

The subject was investigated in two parts, the first being concerned with the physiological significance of the various factors in ventilation, and the second with practical results achieved by the use of various methods of schoolroom ventilation. The complete character of the inquiry in the former section of work is shown by the headings of the chapters in Part I. of the volume under notice. They are first historical, then a general plan of the experiments, a description of the physiological and psychological tests employed, followed by chapters on the effect of atmospheric conditions on the body temperature, on the circulation of blood, on respiration and metabolism, on the performance of mental and of physical work, etc.

The practical conclusions reached confirm the earlier work of Flügge, of J. S. Haldane, and of Leonard Hill. The first and foremost condition to be avoided in regulating the atmosphere of occupied rooms is an excessively high temperature. Even slight overheating beyond 24° C. or 75° F. was found to burden

the heat-regulating system of the body, to increase the rate of respiration, to decrease the amount of work performed under conditions of equal incentive, and to produce a markedly abnormal reaction of the mucous membranes of the nose, which when followed by chill, produced a moist and distended condition of the membranes, calculated to favour bacterial invasion. The commissioners emphasise their conclusion that the dangers of heating of rooms are far more serious in their effect on human health and efficiency than has been generally realised, and that every effort should be made to prevent the temperature of living rooms from exceeding 68° F.

Following an interesting account of the historical development of the practical art of ventilation, Part II. gives the detailed results of the examination of the effects of window-ventilation, of ventilation by fans and by various mechanical ventilation, on the children in elementary schools. Altogether some 216 different schoolrooms were included in the study. Once more it is emphasised that the avoidance of overheating is the primary essential, air change, direction of flow of air, and all other factors being secondary to this. It follows that the school thermometer is the most important article of ventilation equipment, and that a constant and intelligent vigilance is needed if health and comfort, so far as they are influenced by air conditions, are to be secured.

The entire volume is an invaluable mine of information on this important subject, and the investigators whose labours are recorded in it are to be congratulated on the high scientific standard and the certainly beneficial results which their labours will aid in securing.

Our Bookshelf.

(1) *A Manual of Elementary Zoology*. By Dr. L. A. Borradaile. (Oxford Medical Publications.) Fourth edition. Pp. xvi + 671 + 15 plates. (London: Henry Frowde and Hodder and Stoughton, 1923.) 18*s*. net.

(2) *Elementary Zoology for Medical Students*. By Dr. L. A. Borradaile. (Oxford Medical Publications.) Pp. viii + 378. (London: Henry Frowde and Hodder and Stoughton, 1923.) 10*s*. 6*d*. net.

(1) THE publication of a fourth edition of Dr. Borradaile's well-known manual of zoology is at once a tribute to its value as a text-book and the best commendation that can be given to it. New chapters have been added upon sponges and echinoderms, and a number of minor alterations and additions have been made, the chief of which deal with the embryology of mammals and with certain physical properties of protoplasm. These new features enhance the usefulness of the book, which maintains its position as one of the best text-books of zoology for first-year students published in this country. The association of the Nematoda with the Arthropoda, suggested by their position in this book and by the author's specific comment on this point on p. 329, is interesting in view of the recent discussion on the subject at the British Association meeting at Liverpool.

(2) This book is to all intents and purposes an abridged form of Dr. Borradaile's larger manual, containing only such parts of the latter as chiefly concern the medical student preparing for his first professional examination. As such it retains the general form and treatment which have won approval in the larger book, and may be recommended with confidence. The material, however, seems to have been selected with strict reference to existing syllabuses. We cannot but regret that the author did not seize the opportunity to produce a text-book for medical students which would emphasise for them the importance of zoology and its bearing on their later studies. It could have been done by a somewhat different selection of matter from the manual. The inclusion of the complete chapters on the Protozoa as parasites of man and on platyhelminthes, and the omission of that on the crayfish, would have greatly improved the book from this point of view. It is most important that the medical student should integrate his earlier with his later studies, and we feel that he would appreciate his first-year zoology course the more, and approach it in a different spirit, were its relation to his medical work more clearly set out.

A text-book of zoology for medical students without any reference to man as an animal is surely an anomaly which must sooner or later be removed. It is true that the medical student studies man in his later years with an intensity that he cannot give to the types in his zoology course. But the study is apt to be a detached one, and in a book of this type a chapter on the zoological position and characters of man would not be out of place and would, we feel sure, be of enormous value.

American Petroleum Refining. By H. S. Bell. Pp. xiv + 456. (London, Bombay and Sydney: Constable and Co., Ltd., 1923.) 24*s*.

THE claim put forward by the author, that "no volume has yet appeared which is devoted particularly to a presentation of information and data desired by the refiner," is to a large extent true, since much of the available literature dealing with the refining of petroleum is written either for the research laboratory or for the industry as a whole. The work under notice treats the subject throughout from the point of view of large-scale operation based entirely on American practice, and should concern chiefly the chemical engineers of the companies operating in that country. It is doubtful whether it will have a much wider influence except where refinery practice follows on American lines. On the other hand, for those refiners who, not having seen or studied American methods first-hand, are desirous of gaining some general information regarding the system and trend of operations there, it is a most useful volume.

The reviewer, having recently had opportunities of observing American refinery practice in New Jersey, California, and the Gulf States, misses in this volume a description of certain types of plant and methods much in vogue at the present time. The author deals chiefly with eastern and middle-west practice, rather implying

that this typifies all other throughout the country; while this is true broadly speaking, one is surprised at the lack of information on current Californian practice, for example, considering the enormous amount of oil refined within that State and the wonderful progress there made in refining technique during the last few years. The paragraphs on reservoir storage of oil could with advantage be brought up-to-date: a 750,000 barrel capacity reservoir (quoted on page 308) is small compared with the two- to three-million barrel reservoirs now in use in Southern California.

H. B. MILNER.

Elementary Thermodynamics of Automobile Engines. By E. H. Hamilton. Pp. xi+287. (New York and London: McGraw-Hill Book Co. Inc., 1923.) 15*s.*

IN a country where every alternate household owns an automobile, it may be natural for the study of thermodynamics to be entered by this gateway, but to English readers—at present—it comes with something of a shock. We have grown accustomed to the plan of studying general principles first and their application later, but it is interesting to find that in this product of the labours of a member of New York University it is thought they may with advantage be combined.

Much the most interesting chapter is that on detonation; it contains the first discussion which we have seen in book form of the recent anti-detonation research work by certain American automobile builders. On the scientific aspect of detonation the book is far from representing the most recent information on the subject, but the space given to the topic shows the growing realisation that the future development of the engine depends upon a solution of this difficult but fascinating problem. The author considers that the tetra-ethyl lead, used in the United States in the formation of the so-called "ethyl gas," is the most promising anti-knock compound yet found, but he does not give any account of its mode of action.

An attempt is made in the final chapter to foreshadow the future of the engine. Supercharging, as originally proposed by Sir Dugald Clerk, is one of the improvements prophesied; also the adaptation to the automobile engine of compression ignition.

Practical Bee Anatomy: with Notes on the Embryology, Metamorphoses and Physiology of the Honey Bee. By Annie D. Betts. (The Apis Club Library, vol. 1.) Pp. 88. (Benson, Oxon.: The Apis Club, 1923.) n.p.

THE aim in this series is to provide a library on the science and practice of bee culture in all its important phases. This first volume is a manual of the anatomy, both gross and minute, and a practical guide to the methods of dissecting and setting up microscopical preparations. Little, if any, knowledge is assumed in the reader; yet the author does not hesitate to deal with advanced topics in insect anatomy and in general cytology; and successfully. The commonly accepted view of the respiratory mechanism of insects does not, at any rate as regards the honey bee, satisfy Miss Betts; and she advances and supports with strong evidence a new theory that deserves the attention of entomologists. Briefly, she is of opinion that the prothoracic spiracles serve for the escape of air that enters but is prevented from escaping at the abdominal spiracles. Some of the illustrations on the twelve plates are difficult to make out, but with this reservation the book can be commended to the student of apiculture as a trustworthy and up-to-date guide.

Smith's General Chemistry for Colleges. Revised and rewritten by Prof. James Kendall. Pp. xiii+747+8 plates. (London: G. Bell and Sons, Ltd., 1923.) 10*s.* 6*d.* net.

ALTHOUGH Prof. Kendall has much improved this book, the peculiar tendency to dogmatise which was noticeable in earlier editions still persists in many places. The discussion on the discovery of oxygen (p. 28) and that on osmotic pressure (p. 523) are cases in point. Several errors present in earlier editions remain, *e.g.* the statement (p. 286) that ozone is formed by passing "electric waves" through oxygen, that osmic acid is reduced in staining tissues to "metallic osmium" (p. 630), that the first reaction of HCl on MnO_2 is "undoubtedly" the formation of $MnCl_4$, etc. The peculiar method of presenting the molecular theory, although modified by the reviser, is still, probably, less attractive than the usual procedure. Apart from these minor defects the book is excellent. The printing and illustration are good, and a wide range of subjects is treated in a clear and interesting manner. The brief account of atomic structure and the Lewis-Langmuir theory is particularly well done—and not overdone.

Technical Arithmetic. By R. W. M. Gibbs. Pp. viii+168. (London, Glasgow and Bombay: Blackie and Son, Ltd., 1923.) 3*s.* 6*d.* net.

THE special features of this book are: a full treatment of logarithms and the slide rule; graphical solution of algebraic equations and numerical trigonometry up to the solution of triangles; arithmetical chemistry, and the treatment of variation and limits of approximation. The course is intended for those who, being acquainted with the methods of ordinary school arithmetic up to middle form standard, wish to deal mainly with the application of arithmetic to the elementary problems of science and engineering. Each of the ten chapters consists of a few reference notes followed by examples, some of which are fully worked out. Answers are given at the end. The book should be quite useful for the purpose for which it is designed. There is an error in the formula of Ex. 30 on p. 120.

Electrical Measuring Instruments and Supply Meters. By D. J. Bolton. (Directly-Useful Technical Series.) Pp. xvi+328. (London: Chapman and Hall, Ltd., 1923.) 12*s.* 6*d.* net.

THIS book gives descriptions of practically every electrical measuring instrument and meter used in practice. The instruments are grouped well together in the various chapters under such headings as electrostatic voltmeters, induction instruments, alternating current galvanometers and oscillographs, etc. The principles on which the various instruments act can be understood without much difficulty from the descriptions given. The book concludes with 29 questions of examination type on electrical instruments; the answers are provided, and complete solutions are also given to the more difficult questions. These will prove a help to students. The book will be useful to the electrician as a work of reference.

Letters to the Editor.

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Heliotherapy and Phototherapy.

IT is to be regretted that in the brief historical review on phototherapy which appeared in NATURE of December 15 under the title "The Treatment of Disease by Artificial Light" no reference is made to the work of Dr. O. Bernhard, of St. Moritz. Dr. Bernhard is one of the founders of modern phototherapy. He discovered in 1902 the remarkable action of sunlight at the high altitude of the Engadine on the healing of wounds, and he was then led to investigate the general therapeutic action of sunlight in other surgical conditions, including surgical tuberculosis. A few years ago he reported that among the first 1000 cases of surgical tuberculosis treated by him he obtained 858 cases of cure and 120 of definite improvement. He is, however, careful to point out that heliotherapy is not a specific against tuberculosis, but like Sir Henry Gauvain looks upon it as a powerful adjuvant. It was Dr. Bernhard's early observation in 1902 which induced Dr. Rollier in 1904 to open his sanatorium at Leysin, with the brilliant results which are now so well known.

The neglect of Dr. Bernhard's work in Great Britain is the more remarkable as he is the author of two excellent monographs on the subject—"Heliotherapie im Hochgebirge mit besonderer Berücksichtigung der Behandlung der chirurgischen Tuberkulose" (Stuttgart, Enke, 1912) and "Sonnenlichtbehandlung in der Chirurgie" (Stuttgart, Enke, first edition 1917, second edition 1923). In these volumes Dr. Bernhard gives not only the clinical aspects of the subject, but tries to place it on a sound physiological basis. Dr. Bernhard goes very fully into the literature, and the volumes mentioned are a mine of valuable and interesting information on the physics and physiology of heliotherapy. Thus, in his monograph published in 1917, Dr. Bernhard points out the action of sunlight as an important factor in the ætiology of rickets, and gives a striking example.

In connexion with the article in NATURE of December 15, two points may be mentioned. Dr. Bernhard recognises that the effect of sunlight can be imitated by artificial light. But he gives weighty reasons for his view that the therapeutic value of sunlight is superior to that of artificial light, and he discusses in detail the importance of factors other than light, such as the radiant energy of sunlight, climatic conditions, which form part of heliotherapy as distinct from phototherapy. W. CRAMER.

Imperial Cancer Research Fund,
8-11 Queen Square, W.C.1.

The Thirty-two Classes of Crystal Symmetry.

THE fact that crystals may be classed according to their symmetry into thirty-two different classes is widely known, but there are very few who could enumerate all these classes, or state the exact symmetry that each possesses. They are not, as a rule, arranged on any intelligible principle, nor are the various names they have received generally self-explanatory or easy to remember. It has been proposed, indeed, to refer to them by consecutive numbers, like the omnibuses of the London streets, but this is a counsel of despair.

The accompanying table (p. 81) affords an arrangement, a nomenclature, and symbols, which have at least the merit of simplicity. They can be readily understood, and remembered without difficulty, while the relations that exist between the symmetry of the different classes are seen at a glance.

They are, in the first place, arranged according to the highest axial symmetry in the crystal. This may be two-fold—digonal; three-fold—trigonal; four-fold—tetragonal; or six-fold—hexagonal. Each occupies a column. There is, in addition, a column for classes with no axial symmetry, and another for those with four trigonal axes of symmetry—in other words, cubic crystals.

The columns correspond to the crystallographic *systems*. The only exception is the digonal column, which includes two systems, the monoclinic and the orthorhombic.

The horizontal rows possess an importance equal to that of the columns, for in every class in the same row the same relation exists between the terminations or ends of the principal axis or axes of symmetry. These may be unlike, or related to one another by some form of symmetry, either a centre of symmetry, a lateral digonal axis, or the *inverse* character of the principal axis of symmetry. The last requires a word of explanation.

The nature of an ordinary or simple axis of symmetry may be expressed by saying that if the crystal is rotated about it through a fraction of a circle of which the denominator is 2, 3, 4, or 6, it will coincide exactly with its original configuration. If, on the other hand, it is necessary, in order to obtain such coincidence, not only to rotate the crystal about the axis of symmetry, but also to subject it to inversion—that is to say, to the reversal of every direction in it—the axis is said to be an inverse axis. The importance of inverse axes was first pointed out by Prof. Hilton.

The nomenclature employed is somewhat analogous to that adopted by Sir Henry Miers. The name of each system is followed by an adjective expressing the relation between the terminations of the principal axis of symmetry. If the principal axis of symmetry lies in two or more planes of symmetry, so that the succession of faces round it is the same in both directions, the syllable "di" is prefixed to the name of the system. Such classes form the last three rows of the table.

The symbols scarcely require explanation: the first part expresses the cyclic number of the principal axis, the second the presence or absence of planes of symmetry intersecting in the principal axis of symmetry, and the third the relation between the terminations. The table shows the "symmetry number" of Shearer in each class; this expresses the greatest number of similar faces that can exist in any class. In two rows it is equal to the cyclic number of the principal axis of symmetry. In four it is twice that amount, and in one row four times.

Two classes, the hexagonal inverse and dihexagonal inverse classes, appear at first sight to be trigonal, but they are essentially hexagonal.

In each class the information is given in the following order: (1) symbol, (2) name, (3) substance crystallising in the class, (4) symmetry, (5) symmetry number. "Centre" means centre of symmetry, and ii., iii., iv., vi. indicate digonal, trigonal, tetragonal, and hexagonal axes of symmetry.

Further details and explanations will be given in a volume by Mr. George M. Davies and myself, shortly to be published. JOHN W. EVANS.

TABLE SHOWING THE THIRTY-TWO CLASSES OF SYMMETRY.

Distinctive axial symmetry in the different classes. Symbol expressing the cyclic number, k, of such symmetry.	Classes without axial symmetry. I	Classes with digonal symmetry only. II	Classes with one axis of tetragonal symmetry. IV	Classes with an axis of hexagonal symmetry. VI	Classes with one axis of trigonal symmetry. III	Classes with four axes of trigonal symmetry. 4 III (=12) or C
Names of Systems.	TRICLINIC.	MONOCLINIC AND ORTHORHOMBIC.	TETRAGONAL.	HEXAGONAL.	TRIGONAL.	TETRA-TRIGONAL OR CUBIC.
MONOCYCLIC, M. No planes of symmetry intersecting in the principal axes of symmetry.						
n, the symmetry number of Shearer, is shown in parentheses.		MONOCLINIC.				
UNITERMINAL, Mu. Terminations of the principal axes of symmetry unlike (hemimorphic). $n=k$	I Mu *Triclinic uniterminal (asymmetric).* CALCIUM THIOSULPHATE. No symmetry. (1)	II Mu *Monoclinic uniterminal.* CANE SUGAR. ii. axis. (2)	IV Mu *Tetragonal uniterminal.* WULFENITE. iv. axis. (4)	VI Mu *Hexagonal uniterminal.* NEPHELINE. vi. axis. (6)	III Mu *Trigonal uniterminal.* SODIUM PERIODATE. iii. axis. (3)	4 III Mu or C Mu *Tetra-trigonal uniterminal.* ULLMANNITE. 4 iii. axes+3 ii. axes. (12)
CENTRAL, Mc. Centre of symmetry $n=2k$	I Mc *Triclinic central.* ALBITE. Centre. (2)	II Mc *Monoclinic central.* AUGITE. ii. axis+plane of symmetry+centre. (4)	IV Mc *Tetragonal central.* SCHEELITE. iv. axis+plane of symmetry+centre. (8)	VI Mc *Hexagonal central.* APATITE. vi. axis+plane of symmetry+centre. (12)	III Mc *Trigonal central.* PHENAKITE. iii. axis+centre. (6)	4 III Mc or C Mc *Tetra-trigonal central.* PYRITE. 4 iii. axes+3 ii. axes + 3 axial planes of symmetry+centre. (24)
INVERSE, Mv. Terminations of the principal axes of symmetry connected by their inverse character. $n=k$		II Mv *Monoclinic inverse.* CLINOHEDRITE. Inverse ii. axis= plane of symmetry perpendicular to axis. (2)	IV Mv *Tetragonal inverse.* No example known. Inverse iv. axis =ii. axis. (4)	VI Mv *Hexagonal inverse.* No example known. Inverse vi. axis= iii. axis with plane perpendicular to it. (6)	There are no *odd* inverse axes; though VI Mv is apparently trigonal, it is really hexagonal.	
		ORTHORHOMBIC				
HOLOAXIAL, Mh. Terminations of the principal axes of symmetry connected by digonal axes at right angles to them. $n=2k$		II Mh *Orthorhombic holoaxial.* EPSOMITE. 3 ii. axes. (4)	IV Mh *Tetragonal holoaxial.* STRYCHNINE SULPHATE. iv. axis+4 ii. axes. (8)	VI Mh *Hexagonal holoaxial.* QUARTZ above 570° C. vi. axis+6 ii. axes. (12)	III Mh *Trigonal holoaxial.* QUARTZ below 570° C. iii. axis+3 ii. axis. (6)	4 III Mh or C Mh *Tetra-trigonal holoaxial.* CUPRITE. 4 iii. axes+3 iv. axes+6 ii. axes. (24)
DICYCLIC, D. Two or more planes of symmetry intersecting in the principal axes of symmetry.						
UNITERMINAL, Du. (hemimorphic). $n=2k$		II Du *Orthorhombic uniterminal.* HEMIMORPHITE. ii. axis+2 planes of symmetry. (4)	IV Du *Ditetragonal uniterminal.* SUCCIN-IODIMIDE. iv. axis+4 planes of symmetry. (8)	VI Du *Dihexagonal uniterminal.* IODYRITE. vi. axis+6 planes of symmetry. (12)	III Du *Ditrigonal uniterminal.* TOURMALINE. iii. axis+3 planes of symmetry. (6)	4 III Du or C Du *Tetra-ditrigonal uniterminal.* TETRAHEDRITE. 4 iii. axes+3 inverse iv. axes=3 ii. axes + 6 diagonal planes of symmetry. (24)
CENTRAL, Dc. (holohedral). $n=4k$		II Dc *Orthorhombic central.* OLIVINE. 3 ii. axes+3 planes of symmetry +centre. (8)	IV Dc *Ditetragonal central.* ZIRCON. iv. axis+4 ii. axes +5 planes of symmetry+centre. (16)	VI Dc *Dihexagonal central.* BERYL. vi. axis+6 ii. axes +7 planes of symmetry+centre. (24)	III Dc *Ditrigonal central.* CALCITE. iii. axis+3 ii. axes +3 planes of symmetry+centre. (12)	4 III Dc or C Dc *Tetra-ditrigonal central.* SPINEL. 4 iii. axes+3 iv. axes+6 ii. axes+ 3 axial and 6 diagonal planes of symmetry+centre. (48)
INVERSE, Dv. $n=2k$		(Identical with II Du.)	IV Dv *Ditetragonal inverse.* CHALCOPYRITE. Inverse iv. axis= ii. axis+2 other ii. axes+2 planes of symmetry bisecting the angles between the latter. (8)	VI Dv *Dihexagonal inverse.* BENITOITE. Inverse vi. axis = iii. axis with plane of symmetry perpendicular to it+ 3 ii. axes+3 other planes of symmetry passing through the inverse axis and the ii. axes. (12)	There are no *odd* inverse axes. Though VI Dv is apparently trigonal, it is really hexagonal.	

Thunderstorms, Mammato Clouds, and Globular Lightning.

MR. EVERSHED's description in NATURE of December 22, p. 902, of a sound emanating from a thunder-cloud before the storm begins is new to me: I did not hear such a sound in Simla, nor have I come across a reference to this phenomenon in the large literature on thunderstorms. I see no reason to doubt the correctness of the observation, but whether the sound has its origin in the electricity, the rain or the wind which accompanies a thunderstorm, I am unable to say, and do not wish to guess for fear of starting another long discussion in NATURE.

Mr. Dobson, in his letter on mammato clouds in NATURE of December 1, p. 793, says "Any satisfactory explanation of the formation of this type of cloud would be welcome." May I accept this invitation and put forward a new explanation?

Let us imagine a column of the atmosphere with cloud above a certain height and clear air below. Now withdraw air from the foot of the column so that the whole column of air sinks. The air below the plane of separation between clear air and cloud warms up at the adiabatic rate for dry air, while above this plane the air warms up at the adiabatic rate for saturated air. These rates may be taken to be 10° C. and 6° C. per 1000 metres of descent respectively. Thus the air above the plane of separation becomes relatively colder than the air below and equilibrium is disturbed, the cold cloud-laden upper air tending to fall through the warm air below. If this process takes place very slowly and over a large area, the penetration of the upper cold air into the lower air will occur in the form seen in mammato clouds.

This is not the place to go into details of the process, but I may remark that the condition of the atmosphere immediately after the passage of a thunderstorm is very favourable for this process to take place. The air has recently been churned up so that the appropriate adiabatic lapse rates have been established in the cloud and in the air below, and therefore a very small downward component will quickly produce instability at the plane of separation. Also we know that there are violent ascensional currents in a thunderstorm, therefore there must be a corresponding descent of air which probably takes place as a slow settling of the whole air mass over a large area in the rear of the storm. Except in connexion with thunderstorms, appreciable downward motion within the atmosphere is extremely rare, hence mammato clouds are seldom seen except associated with thunderstorms.

While I am writing I should like to refer to one point in connexion with the discussion on globular lightning which is now taking place in NATURE. Mr. E. Kilburn Scott suggests in NATURE, November 24, p. 760, that "the ball may be a mass of concentrated nitrogen oxides." A similar suggestion was made in the *Philosophical Magazine*, volume xxi., p. 630, by Mr. Thornton, but he suggested that the ball was composed of ozone. Now the difficulty with all such explanations is to understand how the ball is held together. If the light given off is caused by chemical combination, the temperature of the gas in the ball must be very high, and this would accelerate the natural mixing which takes place when a mass of gas is introduced into an atmosphere of another gas. I am unable to imagine any process by which a mass of hot glowing gas can hold together except in some form of vortex ring or whirl as suggested by Sir Oliver Lodge. But I know of no evidence to indicate such a whirl, nor can I conceive how it could be formed, while there is good evidence that the ball of globular lightning has not the nature of a flame.

G. C. SIMPSON.

Meteorological Office,
Kingsway, W.C.2,
December 24.

Temperature Periods in the Emission of Occluded Gases from Iron.

IN NATURE of May 13, 1922, one of us reported that, by means of thermo-electric measurements, we had found a periodicity in the properties of iron as a function of temperature such that the periods approximately coincided with the hundreds on the centigrade scale (see also *Annalen der Physik*, vol. 67, pp. 227 and 236, and vol. 68, p. 67, 1922). We have now discovered that the same periodicity also occurs when one measures the speed at which occluded gases are given off from iron upon a similar rise in temperature.

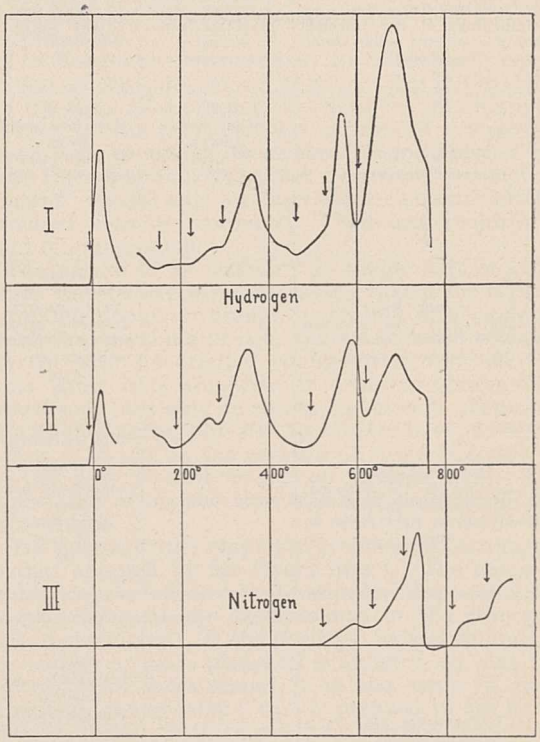


FIG. 1.—Curves showing relation between pressure increase per minute and temperature for iron containing occluded hydrogen or nitrogen.

The accompanying diagram (Fig. 1) shows some of the results we obtained with electrolytic iron containing occluded hydrogen or nitrogen. The specimens were placed in a quartz-tube connected to a manometer, and the apparatus was evacuated. The temperature was raised 2° per minute, and the pressure was observed at intervals of two minutes. The ordinate in Fig. 1 is the increase of pressure per minute, taken as a mean value for twelve minutes. Curve I was obtained with a specimen having a large percentage of hydrogen. As it was chilled off with liquid air, there took place, upon the subsequent rise in temperature, an emission of gas as early as at −5° C.; that is, below the ordinary temperature. As the temperature rose from room temperature upwards, there occurred an accelerated emission of gas at approximately 150°, 220°, 300°, 460°, 530°, and 600°, thus with an average interval of 100°. The

irregularities that occur may be ascribed to the large percentage of hydrogen. Iron possessing less hydrogen gave a curve II, in which the weaker accelerations no longer appear, but where the remainder, in consequence of the greater purity of the iron, lie throughout in the neighbourhood of the hundreds on the centigrade scale. At the point of de-magnetisation, about 760°, a gas-absorption takes place, which renders the examination of the higher temperatures difficult, especially as hydrogen is given off. Curve III shows the emission of nitrogen. This occurs first at about 500°, and is afterwards accelerated at about 600°, 700°, 800°, and 900°.

G. BORELIUS.
F. GUNNESON.
Physical Laboratory, Technical High-School,
Stockholm, November 15.

Government Publications and their Distribution.

THE rules of the Civil Service preclude any expression of my opinion on the economical policy of the Government. Even an official, however, may be allowed to state that the museum reports referred to in the leading article in NATURE of December 29, dull and uninviting though they were even in their best days, greatly help his work, whereas the present skeletons (to use your term) are useless to him.

The attractive appearance and interesting matter of the reports from American museums, which you contrast with those of this country, are perhaps due to the necessity laid on those museums of drawing money directly from individuals, whereas our national museums receive appropriations from the tax-produced revenue of the whole country. So long as the grant from the State is sufficient, the museum can spend its energy better than on appeals to the public; when the grant is reduced, the museum has no funds even for a sprat to catch a whale. In this dilemma we welcome the aid of the Press, both public and technical.

F. A. BATHER.

I TRUST the timely protest made in NATURE of December 29 against the recent action of the Government in restricting the distribution of its publications will meet with the support it deserves. Every scientific worker with any patriotism must long ago have been ashamed at the parsimonious manner in which the world's greatest Government distributes the results of the scientific activities of its various departments. The type, paper, and so-called covers of the publications of the Geological Survey, for example, have been a disgrace to any scientific institution, and now that the valuable work these publications unquestionably contain is to be made even more inaccessible, the time has surely arrived when every one should use his utmost to protest.

Not long ago, on somewhat similar lines, and presumably for somewhat similar reasons, the Government decided that the hand-coloured editions of its geological maps should be increased in price in proportion to the amount of work contained in each map. If this system were logically carried out surely the cost of the preparation of the map, including field work and office work, should have been taken into consideration, in which case probably not a single copy would have been sold. As it is, unquestionably the unreasonable prices charged for these maps has considerably interfered with, if not in some cases entirely stifled, amateur research in certain geological regions, and as such amateur work costs the Government nothing and is invariably placed at its disposal through the media of the publications of the learned societies, the government department concerned is cutting its own throat by this action.

Writing as one whose work necessitates consulting scientific publications on a fairly large scale, I have been struck by the facilities given for research not only by our American friends, who unquestionably lead the way, but also by most of the countries the publications of which it has been my lot to examine. In every instance there is an anxiety to be obliging, which makes one truly ashamed of oneself when asked to reciprocate in the way of supplying information or publications issued by our own Government.

The journals, magazines, and reports issued by the scientific departments of H.M. Government are of unquestionable value, and surely the value is greater or smaller according to the extent to which they are readily available to the public. Any attempt to curtail their distribution is certainly interfering with the scientific progress which the very issue of these publications would seem to indicate.

T. SHEPPARD.
The Museums, Hull.

The Gorilla's Foot.

WITH reference to the correspondence which has appeared in NATURE on the photograph of a cast of a gorilla's foot taken by Mr. Akeley, I should like to direct attention to a possibility which Sir Ray Lankester and Mr. Pocock appear to have neglected, namely, that the particular specimen of gorilla which was the subject of the cast may have had an abnormal foot.

The photograph of the cast is certainly deceptive, inasmuch as the forward position of the great toe gives an erroneous impression of its relation to the other toes, but, notwithstanding this, the foot of this gorilla appears to be distinctly different from the ordinary gorilla's foot, and it is possible that Mr. Akeley obtained by chance an interesting abnormality.

FIG. 1.—Abnormal human foot.

With this I send a photograph (Fig. 1) of a human foot described in a paper now in course of publication in the *Journal of Anatomy*, in which the anthropoid appearance of the hallux is much more startling than the human appearance of the same member in the gorilla's foot of Mr. Akeley.

If such abnormalities occur in the human species we must surely admit the possibility of a similar but opposite abnormality in the anthropoids.

SYDNEY SMITH.
Cairo, December 23.

THE rare condition to which Prof. Sydney Smith directs attention has been regarded as a relapse to a

Simian stage in the evolution of man's foot. As Prof. Smith explains in his paper in the *Journal of Anatomy*, the " thumb-like " digit of this human foot represents not the whole, but only a half of the normal great toe. The cleft which separates the thumb-like digit from the rest of the foot does not correspond to the fork between the great toe and sole of a monkey's foot, but represents an abnormal cleft between the two halves of the great toe. The other or buried half of the great toe is represented by the first of the *five* digits shown in the photograph. The separated digit in such cases represents a spurious " thumb."

ARTHUR KEITH.

Experiments on *Ciona intestinalis*.

IN a letter published in NATURE of November 24, p. 759, Prof. MacBride stated that when Dr. Kammerer cut off only the oral siphon, the regenerated siphon was of the same length as its predecessor, but when both siphons were cut off, then long siphons were regenerated.

In the issue of NATURE for December 8 is a letter from Dr. Kammerer in which he mentions that Mingazzini had previously found that regenerated siphons in Ciona were longer after each regeneration. I have looked up Mingazzini's paper on the subject to which Dr. Kammerer gives the reference, namely, Bolletino Soc. Nat. Napoli, vol. v., 1891, and the statements there made are directly the reverse of that made by Prof. MacBride as quoted above. The following are the words in the original Italian :

" Queste esperienze furono praticati tanto tagliando i sifoni boccali e quelli cloacali su diversi esemplari, quanto tagliando contemporaneamente e sullo stesso esemplare i due sifoni." " Anzi, come legge generale, si vedera che tanto l' uno quanto l' altro, dope che si erano rigenerati, avevano una lunghezza maggiore dei sifoni non rigenerati."

Thus it is distinctly stated that in some cases the buccal and cloacal siphons were cut off in different individuals, sometimes in the same individual, and that in either method a regenerated siphon showed increased length.

It is to be noted that Dr. Kammerer in his letter in NATURE of December 8 does not confirm the statement of Prof. MacBride in the issue of November 24.

J. T. CUNNINGHAM.

East London College,
Mile End, E.1, December 29.

Deferred Annuities (Two Rates of Interest).

I HAVE read with much interest Mr. Palin Elderton's letter which appeared in the issue of NATURE for January 5.

As Mr. Elderton correctly points out, the application of Mr. George King's formula, or two-rate rule, gives lower present-values for immediate-annuities than does the application of the single-rate of interest to both remuneration and redemption, which, it may be mentioned, is the method adopted in Inwood's principal tables.

King's rule for immediate-annuities has been used generally in the mining profession for a number of years, because that rule gives lower values and satisfies the Estate Duty Department.

But while, for immediate-annuities, King's rule produces lower present-values than Inwood's, King's rule for periods of deferment works the other way ; it does not, as the period of deferment lengthens, reduce the values at the rapid rate which Inwood's consistent-rule does.

Mr. Elderton's contention, as I understand it, is that the values obtained by King's rule for immediate-entrance should be discounted by the more stringent Inwood single-rate method, so as to produce a lower value invariably than would be obtained by King's rule for deferred-annuities. His suggestion is the same as that stoutly advocated by Hoskold, who in his 1877 edition devoted 45 pages to tables of deferred-annuities and furnished 9000 present-values. These values are the same as those given by Mr. Elderton in the last column of his illustrations.

The only question, then, is which rule ought a mineral valuer to use ? The late Mr. J. C. Denmead, an actuary of sound knowledge and ability at the Estate Duty Department, strongly condemned the use of Inwood's Tables for deferred-annuities on the ground that for long periods the results were far too stringent. In deference to the views of the Department, mining engineers have been persuaded to discard Inwood and to use King's rule, thus (except for relatively short terms of deferment) arriving at much greater present-values. What Mr. Elderton advises, then, is the use of an even more stringent rule than Inwood's; in fact, he argues for a return to the Hoskold tables long since abandoned in the face of official opposition.

It is quite true, as parenthetically observed above, that for relatively short periods of deferment the values by King's rule are lower than by Inwood's. This is so, of course, because King's values for immediate-entrance are lower than Inwood's, and the deficiency takes a few years to recover, but in long periods of deferment (which are frequent in mining) the present values are very much greater by King's than by Inwood's and are still greater than those determined by Mr. Elderton's (or Hoskold's) formula. The anomaly does not prove Mr. King's method to be wrong or Mr. Elderton's to be right, but there is no doubt the mining profession would gladly adopt Mr. Elderton's method of ascertainment if he could induce the officials at Somerset House to adopt it : the amount payable in Estate Duties would be much lower.

R. A. S. REDMAYNE.

An Improved Form of Pipette.

THE form of pipette shown in Fig. 1 is useful for drawing up and delivering minute quantities of liquid. It can also be used for manipulating microscopic organisms, and in this respect seems to have some advantages over the one commonly used in

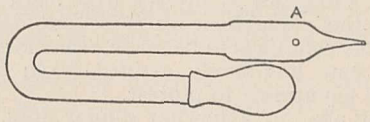


FIG. 1.

biological class-work. The U-shape, by bringing the bulb near to the nozzle, gives a steadier grip, especially if the front part of the tube be enlarged. The U-shape also makes it possible to have an air-hole (A) for regulating the action of the bulb with the finger-tip. If the hole be well placed, it can be closed and opened with a minimum of jar. Pipettes of this form with the nozzle made of thermometer glass can be obtained from Messrs. Reynolds and Branson, Ltd., Leeds.

T. H. TAYLOR.

The University, Leeds.

The Unification of Pure Botany.

By A. G. TANSLEY, F.R.S.

THE history of the development of the science of botany in Great Britain since the great revolution in biological thought brought about by Darwin is an interesting and instructive study. Botany now represents so vast a field of knowledge and research that it is quite impossible for any single individual to gain an intimate first-hand acquaintance with all its different branches. Many research workers spend their lives in cultivating a small area of one portion of this immense territory. Nowadays many of them have very little interest in or understanding of the work of their fellow "botanists." The taxonomy of flowering plants and of the various lower groups, the ecology and general natural history of all this multitude of forms, their gross and their minute anatomy, histology, and cytology; the study of variation and heredity; the great and varied field of modern plant physiology, with its interest more and more centred in the chemical and physical characters of protoplasm and its derivatives; the study of the characteristic aggregates of plant life that we call vegetation; the applications of botany to agriculture and to industry—we need only pass these fields of study rapidly before our minds to realise their enormous range, and the want of connexion in practice between the topics with which a modern botanist may occupy himself.

Yet the whole of the vast field of our knowledge of plant life continues to be called by one name, and most of those who labour in it are still possessed of some sense of community with their fellow-workers. There has always been strong, and hitherto successful, opposition to proposals for formal division of the subject into separate parts, though both logic and practical convenience would seem to dictate such a course. There seems to have been an intuition that division would involve the loss of something too important and too precious to be lightly sacrificed. We have to ask ourselves whether this intuition can be justified on reasoned grounds, whether there is any rallying point from which the science of plants can be regarded as a whole, and presented to those who are beginning its serious study. In order to approach this question intelligently we must cursorily review the historical factors that have determined the existing position.

In recent centuries, that is, after the revival of learning, botany has developed as a result partly of man's natural interest in plants, the living beings which form so great a part of his natural environment and on which he depends so largely for his food, but very markedly as a specific result of interest in the collections of medicinal herbs grown in special gardens attached to the medical schools. The earliest professors of botany in western and central Europe were the curators of these Herb or Physic Gardens, and they taught their students the nature and properties of the plants under their care, and how to distinguish the various kinds. Gradually the scope of these collections widened to include non-medicinal plants, and the effort to bring order into the multitude of forms led to the study of their structure—morphology—and to the creation of systems of classification.

The early professors of botany, while they acquainted themselves with the properties of plants, were necessarily also taxonomists and morphologists—they had to be, in order to cope with the material with which they were concerned. They mostly possessed the type of mind which finds its satisfaction in the study and comparison of objects which present various kinds and degrees of similarity and difference—the type of mind which naturally *observes* and *classifies*—well exemplified by that great pioneer Linnæus. But alongside this primary development of pure botany, another kind of interest showed itself, interest in how plants work, how they get the material which enables them to increase in bulk, what is the nature of this material, how they grow and reproduce themselves. This second type of mind, which naturally *observes* and *experiments*, was notably exemplified by our own countrymen, Andrew Knight and Stephen Hales, forerunners of the modern plant physiologists.

About the middle of the nineteenth century, in Germany especially, there was a great quickening of scientific interest in plants, a great outburst of investigation into the minute structure and life history of plants, and also of experimentation. The two types of interest in plants were both strongly represented in this new movement of "wissenschaftliche Botanik," and they were reflected in the foundation, beside the old professorships of botany, of new chairs of plant physiology, a duplication which exists in most of the larger German universities. But there was no sharp separation of the kinds of study, and the great German pioneers of modern botany were certainly not narrow specialists. In Great Britain, fifty years ago, botany was still almost exclusively represented by systematists and morphologists, among whom were some of our greatest names. Meanwhile Darwin's work had inspired the whole of biology with new life, and there arose a group of eager young men who wanted a different kind of material, which traditional British botany could not give them. They saw in Germany a great mass of new knowledge of the internal structure, life histories, and physiology of plants, and several became pupils of great German botanists who had taken leading parts in the new discoveries. On their return they helped to found in Great Britain the new school of laboratory botany which marked the later seventies and the eighties of last century.

In this school the divergence of the two types of human interest in plants showed itself very plainly from the first. One group of the younger British botanists took up with enthusiasm the work of exploring the structures and life histories of the various groups of plants, another—a much smaller one—the experimental study of function. The influence of Darwin had now become overwhelming. The origin of species by means of natural selection was generally accepted by biologists—it had become biological orthodoxy, but was still in the first flush of its effectiveness. Hence the natural morphologists among the younger men were inspired by a desire to apply the Darwinian theory of evolution to the detailed development of the plant kingdom—to the tracing of the phylogeny of different groups as illustrating the

continuous adaptation of plants to environment. Much of this work was carried out by comparative study of the structures and life histories of living plants, and prominent examples were the great series of comparative studies of the spore-bearing organs of Pteridophytes—the great middle grade of the plant kingdom including the more primitive vascular plants —and of the phenomenon of alternation of sexual and spore-bearing generations which the life histories of these plants regularly show.

Another important factor now came into play. The masterly pioneer work of Williamson had at this time added greatly to our knowledge of the rich flora of the English coal measures, and these beautifully preserved fossils offered a rich field to the trained anatomist, who was able to apply his newly acquired knowledge of the details of structure of living plants to the elucidation of the fossil forms which reached the culmination of their development towards the close of the Palæozoic age. Many of the fossil plants in question clearly belonged to the same order of Pteridophyta—the horsetails, the clubmosses, and the ferns—of which representatives still exist, though in greatly diminished size and numbers. Others, on the contrary, could not be placed in any existing order, though they clearly belonged to the same general grade of organisation. Others again, the vegetative structure of which had long been known, were eventually proved, about the beginning of the new century, to be fern-like plants bearing seeds (Pteridospermeæ), though seeds of a type differing in important respects from those of existing seed plants.

Most of this work, together with the concurrent, energetically pursued comparative investigations of the detailed structure of living forms, was undertaken under the influence, and inspired by the ideal, of tracing out the "genealogical tree" of the plant kingdom, an ideal which was the direct result of the doctrine of organic evolution. The newly discovered facts of structure in both recent and fossil forms of Pteridophytes, among others those relating to their vascular systems, suggested that there were two main lines of descent among vascular plants; one including the cone-bearing small-leaved forms, the other with typically large leaves including the ferns and probably also the seed plants. There seemed a probability that the Pteridosperms had an origin in true ferns, some of which, especially the wholly fossil group of Primofilices, and also existing ferns believed on other grounds to be relatively primitive, they resembled in vascular structure more or less closely. Though their seeds differed in important characters from the seeds of modern plants, there was perhaps a natural tendency to the assumption that "a seed was a seed," and that from some plants not unlike the Pteridosperms the modern seed plants might be descended.

The facts, however, did not carry the same phylogenetic convictions to every one. There was a good deal of difference of opinion as to the connexion or want of connexion between the various groups of Pteridophytes, and as to the lines of descent of the seed plants. It has become more and more clearly recognised that particular, well-characterised plant structures, such, for example, as the archegonium (the type of female organ found in all the Pteridophyta as well as in the non-vascular group of mosses and liverworts), or the seed itself, are not (as was too often assumed, if only implicitly and unconsciously) necessarily homogenetic, *i.e.* indicating community of descent between the plants possessing them. Such organs may well have taken origin independently—and the same conclusion may be extended even to such fundamental structures of vegetative organisation as leaf, stem, and root—along many different lines of descent. On general biological grounds we should indeed expect this to be the case. The conception of homoplasy, or parallel evolution of similar organs under similar external conditions of life, has of course long been familiar to biologists, but we should be prepared for a far wider interpretation of this principle than was originally contemplated. It is not only a question of *particular* external conditions, but also of the limited number of ways in which protoplasm can react to constantly recurring conditions. It is not of course suggested that an organ should not be regarded as strictly homologous within a small well-defined natural group, but that wide phylogenetic conclusions, relating to large series of forms showing gaps in continuity, are rendered additionally unsafe when we consider the likelihood of independent development of what have often been assumed to be phyletically the same structures.

As a matter of fact the search for common ancestors has turned out to be disappointing. The better the different groups of fossil Pteridophyta and of primitive seed plants have become known, the more definitely they have shown themselves independent, and this conclusion has recently been quite clearly stated by the leaders of this branch of botany. One authority goes so far as to doubt whether "missing links" have ever existed, and to suggest that the different groups of vascular plants may have had their origin in primitive water plants (Algæ) at different times in the history of the earth. To put the matter shortly, morphologists have not succeeded in establishing the phylogenetic connexions of the different groups of vascular plants, or even whether they have any connexions. Different groups appear in the geological record, reach a culminating point, and disappear again, either completely, or leaving a few diminished representatives behind. The older (Palæozoic) groups reached a high degree of complexity and show many features strikingly parallel with those of modern plants, but it is only these latter, especially the Angiosperms or modern seed plants, which have developed that flexibility which has enabled them to dominate the highly varied environments presented by the earth's surface. The vast amount of careful and accurate investigation of structure that has been carried out in the effort to establish positive phylogenetic conclusions has, however, immensely increased our detailed knowledge of structure. It has also established that within undoubtedly homogeneous groups there have been certain types of progression, both in vegetative and reproductive structures, and that these have been repeated again and again in different phases of geological history.

Meanwhile the physiologists, in accordance with their different kind of interest in plants, worked on wholly different lines. Thirty years ago plant physiology consisted very largely of quantitative studies of the

functions of the adult plant, such as transpiration, respiration, photosynthesis, etc., under different conditions, and there was a sharp separation between the metabolic functions and the phenomena of "irritability" such as the tropisms—changes in the direction of movement. Each function was studied, deliberately, as much as possible in isolation, and the records were necessarily extreme examples of specialisation, often as little interesting to any one but the specialist as purely morphological studies of particular forms. Morphology and physiology, as practised in those days, were not only essentially divergent but also practically unconnected pursuits, and neither had any immediate bearing on the central problems of plant life. This state of things was conspicuously reflected in botanical teaching, morphology and physiology being generally taught independently, and presented to the student as if they had little or no connexion, as indeed was the fact. This divorce was even crystallised into a formula which stated that the object of morphology was the elucidation of phylogeny, while that of physiology was the study of function. It must often have seemed to the student a mere accident, as it were, that they both happened to deal with plants.

Together with the widening of our knowledge of the functions of the adult plant, a deepening of plant physiology has also been in progress, depending very largely on important advances in physical chemistry, and the application of the results to the activities of living substance which has resulted in the rise of the modern science of biochemistry. This has placed tools in the hands of the plant physiologist of which he is now making good use. Very great advances have been made in our understanding of the real nature of protoplasm and of the modes of action of the living cell. More and more we are able to study these modes of action in terms of actual identifiable substances and their chemical and physical changes, instead of referring them to "functions" of a mysterious entity, protoplasm. In recent years too, *developmental* physiological studies, from different points of view, have been inaugurated, and these are gradually giving us new light on the conditions obtaining in the germinating seed, the seedling, and the young growing plant, and how these conditions lead up to the processes of the adult organism. We are thus beginning to get a real picture of the plant as a developing complex of substances and structures, and of the way in which they act and react upon one another. Recent work upon the actual determination of substances, tissues and organs within the individual plant, such as endodermis, cork, and cuticle, and on the relation of the differences between the primary meristems of root and shoot to the construction of these organs, though still in its infancy, has already begun to throw light on these problems of development.

Here, in the causal study of ontogeny, the development of the individual plant, we have a line of work that should unite the interests, too long widely divorced, of morphologists and physiologists. There have not been wanting far-sighted morphologists who have long been dissatisfied with the tracing of doubtful phylogenies, and have sought in the study of the causal factors of ontogeny a starting point for an attack on the problems of form. But they have seldom had the training necessary for successful advance in this direction. We should boldly claim, as has been claimed by Prof. D'Arcy Thompson, that since the problems of form are in the first instance mathematical problems, the problems of growth essentially physical problems—and, we may add, since the problems of tissue differentiation are essentially biochemical problems—"the morphologist is *ipso facto* a student of physical science." If we are to obtain real solutions of these problems we must get away altogether from the point of view of the Darwinian morphologist, and work on other lines, in which physical and chemical training is essential. Meanwhile, we cannot underrate the great services rendered under the stimulus of the effort to work out the phylogeny of plants, which have enormously increased our detailed knowledge of structure, and thus provided us with numberless unanswered questions.

Some of these questions can be approached with the means now at our disposal; for example, questions of the general form: How do the actual substances and structures of the young growing plant of any given species or strain produce the characteristic structures and properties of the adult? But when we ask how the substances and structures of the embryo, and eventually of the zygote, come to produce those of the young plant, we have to confess that the means of dealing with the problem are at present quite beyond us. When we get back to the zygote we are brought up against its inaccessibility to useful chemical analysis, and we are confronted with the still mysterious "genes" of the Mendelian, those hypothetical entities which the geneticist finds it necessary to postulate in order to explain the results of cross-breeding. It is the stock of genes possessed by the zygote, seated in the chromatin of the cell-nucleus, which are conceived as determining, in the last analysis, the characters of the individual organism derived from the zygote. The cytoplasm of the zygote also plays an important part in its development, and since the cytoplasm of different species is different, and is continuous from mother to offspring, we cannot deny that it must also transmit hereditary characters. The genes of the chromatin only produce their effect in development by interaction with the surrounding cytoplasm, and it is in the cytoplasm, in the vacuoles and in the cell walls that the larger part of the chemical and physical changes, which bring about development, are carried out. We are thus far from being able to ignore the cytoplasm in considering development.

Nevertheless it is primarily the genes of the chromatin that determine the specific characters of the organism. We do not know what genes are. They may be definite chemical substances, they may be molecular complexes, or some may be of one, some of the other nature. But we do know that within the periods of exact breeding experiments carried on for many generations, the genes show themselves as invariable entities, heritable changes in the adult organism occurring as the result of the redistribution or loss of genes at the "reduction division," and not by any demonstrable alteration in the genes themselves. The process of ontogeny ultimately rests on the way in which the genes and their derivatives in the developing organism produce the characters of the adult under the influence of a

particular environment. We can only hope to approach the fundamental problem of how this happens slowly and by degrees. Great as have been recent advances in our knowledge of the physics and chemistry of protoplasm, we are still seriously hampered by want of knowledge in attacking even the easier problems of ontogeny. But a successful beginning has already been made, and ultimately, with deeper knowledge and improved technique, we may get back to the embryo, and perhaps eventually to the zygote and the mysterious genes.

Thus it seems that in the causal study of ontogeny lies the nexus which is capable of reuniting the divided branches of pure botany—taxonomy, morphology, physiology, genetics; and this seems to be equally true of the zoological field. Taxonomy is the natural arrangement of the end results of divergent developments: on one side it rests on descriptive morphology, on the other on genetics. Morphology, as a branch of science, should no longer be described merely as a comparative study of structure with the object of tracing phylogeny: it must take cognisance of the causal explanation of forms and structures. Physiology is not adequately described as the study of function, in the sense of the particular "functions" of the adult organism. It is a study of all the *processes* of the organism in terms of chemistry and physics. Supported by increasing biochemical knowledge, it is the essential means of explaining ontogeny. Genetics, during the last quarter of a century, has performed the great service of making clear the mechanism of heritable variation, which, as Bateson long ago said, is the primary problem of evolution. But the secret of the production and variation of organic structure can never be discovered until we know the real nature and the working in development of the genes themselves; and this mighty problem, the ultimate solution of which must lie in the distant future, can only be approached through the biochemical study of individual development. Substantial advance in this direction is necessary before we shall be in a position to determine the real nature of possible factors in evolution other than the redistribution and dropping out of genes—how, for example, the environment can, as it almost certainly does, affect the hereditary constitution of a race of organisms.

From a point of view such as this, botany—and indeed biology at large—should be presented to the student, if his imagination is to be stimulated to the greatest advantage. Thus he will be placed in the best position to understand the real significance of the subject, perhaps to add to it by his own work. It is unnecessary to say that the main material for teaching cannot be derived from the direct causal study of ontogeny, for the very good reason that we know extremely little about it. But the material used in teaching can be selected with the object of constantly laying stress on the facts and problems of development, of insisting on the search for causal explanations, and of the necessity of seeking them by experiment, of abandoning the deep-rooted and sterilising fallacy—still unfortunately instilled into our school children—that usefulness to the plant is any explanation of the appearance of a structure. In this way the student will be brought from the outset to view the science of plants in the right perspective; he will be led to interest in the most fruitful lines of research, and his training will stand him in good stead no matter what kind of plant study he may take up, whether it be a branch of pure botany, or one of its manifold applications to agriculture or to industry, remote as these may be, to all appearance, from the central problems of plant life. So perhaps we may hope to retain in the future that sense of community between botanists which can only be real if it is based on some real underlying unity of outlook.

British Geological Photographs.

By Prof. S. H. REYNOLDS, Secretary of the British Association Geological Photographs Committee.

FROM time to time articles and notes have been published in NATURE on the work of the British Association Committee for the collection of British photographs of geological interest. It is, however, twenty-five years (March 10, 1898, vol. 57, p. 437) since the last of these articles, by Prof. W. W. Watts, appeared. The collection at that time numbered 1750 prints; it now numbers 6310. It might perhaps be thought that this large number would afford a fairly complete record of the subject. This is very far from being the case. Even in the districts most fully illustrated, such as the Belfast district, Yorkshire, and parts of the south and west of England, there is still much to be done, while many parts of Ireland and some of Scotland are still quite unrepresented. It is, in fact, only when a district is so fortunate as to possess a resident who is keenly interested in such work (as Mr. G. Bingley for Yorkshire and Mr. R. Welch for Antrim) that a really adequate series of photographs has been taken. The photographic survey of the Island of Eigg carried out by Mr. A. S. Reid should be mentioned in this connexion.

Probably one of the most important pieces of work of the committee has been to preserve a record of temporary geological features. Particularly instructive examples of such records are Mr. C. Buckingham's photographs of the nailbournes of Kent and Mr. P. B. Roberts's series illustrating the progress of a wave of erosion at Bexhill. The nailbournes or winterbournes so characteristic of many chalk districts are temporary streams, which in some cases only flow when an exceptionally wet season has raised the level of saturation. Some years may pass between the successive appearances of a bourne, and during such a period the possibility of its reappearance may be lost sight of and buildings may be erected in its path. This happened, for example, at Croydon during the first few years of the present century. Mr. Buckingham's photographs, two of which are reproduced (Figs. 1 and 2), show in a most instructive fashion the contrast in appearance of

a spot according to whether the bourne is or is not flowing.

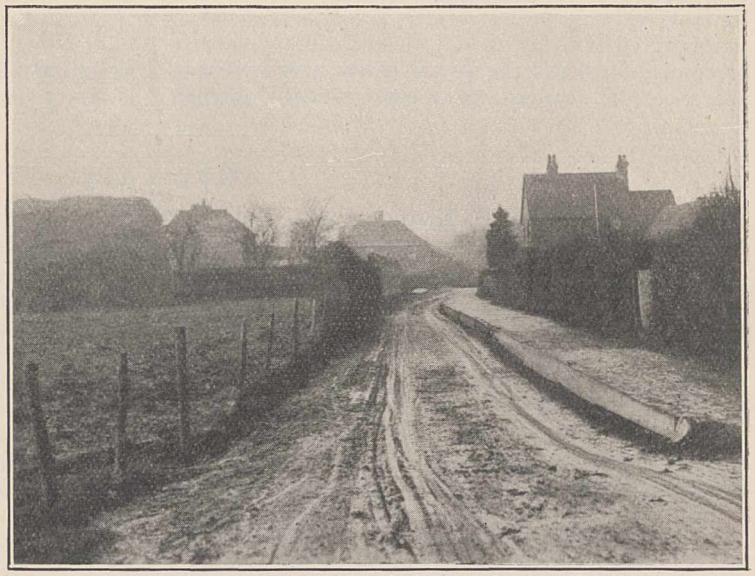
Mr. Roberts's photographs illustrate the remarkable wave of erosion which slowly moved eastward along the south-east coast of England in the winter of 1909–10. We see the esplanade at Bexhill prior to the advent of the erosion wave; the preparations made by means of barriers to lessen its effect; the complete ineffectiveness of these barriers, and the appearance of the coast after the erosion wave had passed on (Fig. 3). Equally interesting is the series illustrating the effects of the "cloud-burst" of August 2, 1891, at Bennachie, near Oyne, Aberdeen, contributed by Mr. J. Ritchie. It may incidentally be remarked that the collection includes no record of the Louth "cloud-burst" of May 29, 1920, and photographs illustrating this would be very acceptable.

Attention may be directed to the series of photographs taken in the caves of the Mendips by the members of the University of Bristol Spelæological Society, which has been doing such admirable work during the last few years in the study of the caves of North Somerset. Of late years, many photographs have been received illustrating a subject which was formerly somewhat neglected, namely, the features shown on the weathered surfaces of rocks, many of the subjects being shown approximately natural size. In this connexion, Mr. Bingley's and Dr. G. Abbott's remarkable series illustrating the magnesian limestone concretions of Durham, and Mr. Bingley's set illustrating the fossil footprints from Storeton quarries, Cheshire, deserve special notice. Some of the very best work has been done by photographers working in association with a local natural history society, *e.g.* that of Mr. Welch in connexion with the Belfast Naturalists' Field Club.

It must be admitted that the committee's collection, which is housed in the library of the Geological Survey at Jermyn Street, is less often referred to than could be desired, but there is no doubt that the selected series published by the committee has proved of great value to teachers of geology both at home and abroad. The published series consists of 72 subjects issued in the form of both prints and lantern slides. It appeared in three issues in 1902, 1903 and 1904, respectively. There were 193 subscribers to the series, and the whole was so successfully managed by the secretary, Prof. Watts, that a clear profit of 130*l.* was made, rendering the committee self-supporting. Had not eight whole-plate photographs and twelve lantern slides beyond the number agreed upon been issued to subscribers the profit would have been 235*l.* The expenses for albums, mounting, postage, stationery, etc., from the date of issue to the present time have all been defrayed from this sum, so that the British Association has been put to no expense. The indebtedness of the committee to Prof. Watts was fittingly acknowledged by a resolution unanimously passed at the Cambridge meeting of the Association in 1904. The resolution was as follows: "That this committee desires to record its admiration of the indefatigable energy shown by its secretary, both in carrying out the original aims of the committee and in bringing to a successful issue the publication of a typical series of geological photographs, services to geological science which cannot well be overestimated."

A second series of geological photographs has long been in contemplation and was taken in hand in 1919.

FIG. 1.—Elham nailbourne at Barham, flowing. Jan. 1904.

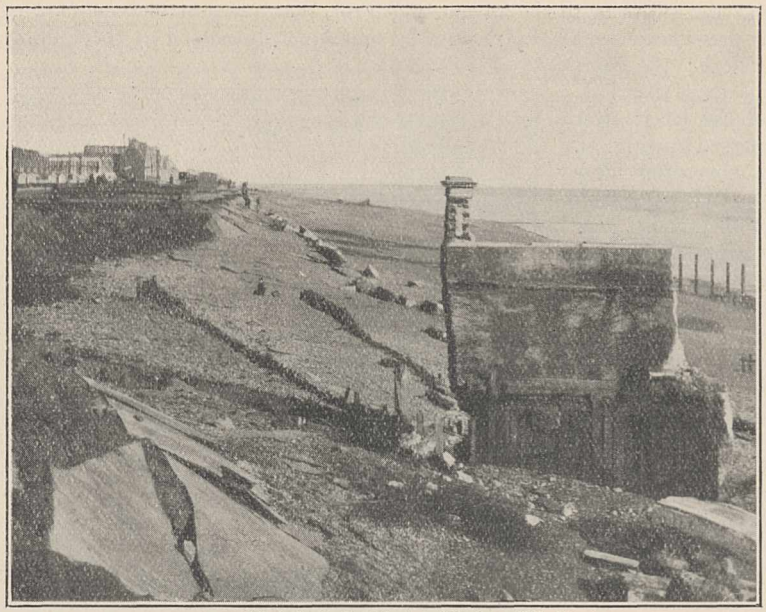


[*Photos by C. Buckingham, 108 High Street, Godalming.*

FIG. 2.—Elham nailbourne at Barham, bourne dry. Jan. 1905.

Subjects were selected and circulars were sent to all former subscribers and to almost every university and other body likely to be interested abroad as well as at home. The number of applications for such a second series proved, however, to be quite inadequate to justify proceeding further in the matter, which is at present in abeyance. The earlier series is still obtainable through the secretary. There is a small duplicate collection of lantern slides and two albums of prints which may be borrowed.

A circular setting forth the objects of the committee and containing also hints on the taking, printing, etc. of geological photographs can be obtained from the secretary, at the University, Bristol.



[*Photo by P. B. Roberts, 9 Westbury Hill, Westbury-on-Trym, Bristol.*

FIG. 3.—Coast erosion at Bexhill-on-Sea. Winter 1909–10.

In the foreground is seen a ruined bastion, and a row of large blocks, the remains of the sea-wall, extend away from it to join the part of the esplanade which is still intact. In the considerable inlet formed by the cutting back of the coast, two barriers of hurdles have been erected in the hope of checking further destruction.

Obituary.

DR. O. KLOTZ.

THE death is announced, at the age of seventy-one, of Dr. Otto Klotz, Director of the Dominion Observatory at Ottawa. He seemed to be in excellent health when he attended the Rome meetings of the Astronomical and Geophysical Unions in May 1922, and his death adds one more to the unexpected losses which have sadly diminished the number of working seismologists in recent years. He had been Director of the Dominion Observatory for some half-dozen years. Dr. W. F. King, who founded that Observatory in 1903, and also started the Canadian Geodetic Survey and other Canadian enterprises, died on April 23, 1916, making a break in the four names which had appeared on the front page of the Journal of the Royal Astronomical Society of Canada (Chant, King, Stupart, Plaskett) since its first number in 1907. Dr. Klotz's name, with the title of Director of the Dominion Observatory, appears on No. 2 of vol. xii. (Jan. 1918), while Mr. Plaskett becomes the Director of the Dominion Astrophysical Observatory, taking charge of the new 72-inch reflector at Victoria, B.C.

In recent years, however, Dr. Klotz's writings have been chiefly seismological. He has published a useful volume of seismological tables, and shown great discernment in making known matters of interest. For example, when Galitzin directed attention to the possible interpretation of the Pamir earthquake of February 18, 1911, as due to the fall of a huge mass of rock, Klotz promptly published a translation of this important paper.

In earlier life Klotz had done much survey work. In 1892 the longitude Greenwich-Montreal was determined by McLeod and Klotz as Canadian observers, Turner and Hollis as English. The observers did not often meet, being usually at opposite ends of a cable, or land-line; but the brief and rare meetings afforded opportunities for hearing something of Dr. Klotz's previous adventures in surveying, usually conducted by long journeys in small boats up and down the Canadian rivers, in territory which could scarcely yet be regarded as civilised. Some dozen years later he was able to extend the arc (carried from Greenwich to Montreal and thence across Canada) to Australia and New Zealand, by means of the new Pacific Cable. The cable was completed on December 8, 1902, and very early use of it was made for this longitude work. As a result of the operations, Dr. Klotz was able to give the longitudes of Vancouver, Fanning, Suva, Norfolk, Southport (Queensland), Brisbane, Doubtless Bay, and

Wellington (N.Z.) with a probable error of about $\pm 0.05^s$ in each case. He returned home through Europe, visiting many observatories on the way, and became a fellow of the Royal Astronomical Society in June 1904.

It seems relevant to recall that Lieut. H. N. Klotz, a nephew of Dr. Klotz, was killed in the Canadian charge north of Ypres on April 23, 1915. He was a graduate of Toronto University, and had been employed as a chemist with the Toronto Rubber Company.

H. H. TURNER.

PROF. J. HARKNESS.

WE regret to notice the death, in his sixtieth year, of Prof. James Harkness of McGill University, Montreal. Born at Derby, Harkness became a scholar of Trinity College, Cambridge, and graduated as eighth wrangler in 1885. After five years at Bryn Mawr College, Pennsylvania, as associate professor and professor of mathematics, he accepted, in 1903, the Peter Redpath chair of pure mathematics at McGill, and resigned it in 1913. He was formerly vice-president of the American Mathematical Society and assisted in editing the Society's Transactions. The degree of LL.D. was conferred on him by McGill in 1921.

Harkness is mainly known in England as the author, jointly with Prof. Frank Morley, of a treatise on the theory of functions of a complex variable (1893) and an introduction thereto (1898). These books, which aim at giving the fundamental ideas at the basis of the subject and avoid all intricate details, provide much the best introduction to the subject that has yet appeared in English. Harkness also collaborated in compiling the section on elliptic functions in the "Encycl. d. math. Wissenschaften." Since 1909 he was a fellow of the Royal Society of Canada and contributed papers on function theory to that Society's Transactions.

MR. LELAND L. DUNCAN.

WE regret to record the death of Mr. Leland Lewis Duncan, the Kentish antiquarian. The field in which he was perhaps best known to the public was that of medieval archæology and ecclesiology, subjects on which he wrote extensively. He specialised in the history of the parish of Lewisham; but while he gave much attention to local historical problems generally, the principal subject of his investigations was the parish church, particularly in the medieval period. Apart from the work of actual investigation, he did a great service to archæology in founding the Lewisham Antiquarian Society in conjunction with Sir Edward Brabrook, Canon Legge, afterwards Bishop of Lichfield, and others. He thus continued the work which had been begun some years before by Sir Flinders Petrie, and, with other members of the Society, did much to promote the investigation of the early and medieval history of south-east London and the adjacent area of Kent on thoroughly scientific lines.

Mr. Duncan also engaged in many investigations outside the Lewisham area in Kent generally, devoting himself particularly to church records and inscriptions, and to wills, subjects upon which, it was widely recognised, his knowledge was both extensive and intimate. His researches were embodied in numerous papers, many of them appearing in *Archæologia Cantiana*, and he was engaged in the preparation of an important treatise on Kentish wills at the time of his death. In his own special sphere of work, Mr. Duncan was regarded as an authority of high standing; but apart from that, his scholarship and accuracy set a standard in medieval research which has reacted to the advantage of archæological studies throughout the whole of south-east England. His position as an antiquarian was recognised by his admission to the Society of Antiquaries so long ago as 1890.

Current Topics and Events.

OUR Supplement this week is of particular interest to observers of the sun, inasmuch as it throws light not only on the somewhat restricted subject indicated by its title, but also on the general problem of the sun's constitution. From the time of Galileo onwards, sun-spots have been almost universally regarded as the most promising key to the solution of this problem, though it was not until Dr. Hale's great discovery of 1908 that this instinctive idea was shown to be justified. We are still far from the whole truth in this matter, but it is the surest sign of progress that a large field, formerly the scene of speculation only, is now thrown open to experimental investigation. Speculation in some instances came very near what is now more confidently believed to be the truth. As Dr. Hale points out, Sir John Herschel and Faye proposed theories of sun-spots almost identical with the view which he himself puts forward, so far as mechanical action is concerned, but the difficulties of reconciling such theories with observation led practically all experienced observers to reject them. It might be added that Herbert Spencer came still nearer to the modern view: not being an observer, he was possibly less susceptible to the difficulties which his contemporaries felt so keenly. The fact which has just come to light, that there is a reversal of polarity in sun-spots (though not in the general magnetic field of the sun) on passing from one cycle to another, is perhaps the most remarkable of the many discoveries which Dr. Hale recounts. We may now, as he indicates, have to deal with a solar period of about 22 instead of 11 years; and if so, the close coincidence between this period and that of Jupiter's revolution round the sun will no longer exist to suggest, as it has done in the past, that sun-spots may be attributable to planetary action. Of great interest also is Dr. Hale's statement that the vortices represented by the hydrogen (Hα) flocculi, which first led him to search for magnetic fields in spots, are apparently secondary phenomena, and that the vortices which give rise to the magnetism seem to lie beneath the photosphere and to have directions independent of those of the hydrogen flocculi. He is of opinion that the dominant electric charge in all *spot* vortices is of the same sign, and that opposite polarities represent opposite directions of whirl.

A contrary assumption, he says, has been made by several writers, though the facts give no warrant for it. It is possible that some misunderstanding on this point may have arisen from the fact that, in his earlier papers, Dr. Hale used the word "electron" indiscriminately for positive and negative ions, but it is clear that there is no conclusive evidence at all with regard to the charge or charges of the whirling particles.

WE have always held that the alleged indifference of the general public to scientific work and achievement is largely due to the indifference with which men of science themselves mostly regard popular interests. Scientific societies are, of course, concerned with the actual advancement of natural knowledge, and it is scarcely their function to interest the general public in it. A valuable service is, however, rendered to science and to the people by the public display of scientific experiments and other devices, or by the delivery of popular lectures. An example of this kind of publicity was the Scientific Novelties Exhibition held at King's College, London, on December 29–January 9 in aid of the King Edward's Hospital Fund for London. This may be regarded as a contribution of the scientific staffs of London colleges to the Fund. Perhaps another year the Medical Schools of the University will themselves arrange for a similar exhibition, as, so far, they have done very little to assist the two science exhibitions which have been held for the Hospital Fund at King's College. To make these exhibitions attractive they must not be of a museum or still-life character, but must chiefly be devoted to demonstrations and similar displays of things in action. The success of the exhibition at King's College has led to a similar undertaking by the Bedford Physical and Radio Society in aid of the Bedford County Hospital and the local blind, and this exhibition, which, under the title of "The Wonderland of Science," was held at Bedford School on January 10-12, excelled in many respects that held in London. The exhibits covered a wide range of scientific experiment and mechanical ingenuity, and all who were concerned in its organisation are to be congratulated upon the success of their efforts. The Duchess of Bedford took the greatest interest in the enterprise from the beginning, and herself opened the Exhibition. We hope that other provincial centres will follow the example so excellently set at Bedford.

WE publish in another part of this issue an article by Mr. A. G. Tansley, on "The Unification of Pure Botany," which presents, from rather a different angle, and with less technical detail, the main argument of the author's presidential address, delivered on September 13, to Section K (Botany) of the British Association at its recent Liverpool meeting. In this abbreviated and more generalised form Mr. Tansley sketches the development of the different aspects of botanical teaching and research and puts forward a plea for unification which will be appreciated by all biologists.

AT last we have in London, in the rooms of the Royal Academy, a comprehensive exhibition of Swedish graphic and plastic art, from the brilliant period that closed the nineteenth century. Here one can see all the poetry of the Swedish landscape in the works of Prince Eugen; its wild life in the intimate studies of Bruno Liljefors; its men and women in Zorn's peasant girls, the fishermen of Carl Wilhelmson, and the family life of Carl Larsson. Among the finely perceptive portraits by Richard Bergh is one of Arrhenius. One cannot mention all one would like to, but the horses of Nils Kreuger should find a place here, and those two marvellous bits of painting of ice and hoar-frost by Gustaf Fjaestad. The exhibition, which has been arranged by a special Swedish committee in co-operation with the Anglo-Swedish Society, is open until February 15.

DR. W. H. GIBSON, writing from Belfast, suggests that scientific societies should ascertain the total amount required for the publication of their proceedings, etc., and that an appeal should be made to the public for a capital sum to yield this annual income. He thinks the income from the capital should be controlled by a central organisation which would prepare and issue sets of classified abstracts. The societies would retain their autonomy, but all costs of printing and publication would be borne by the central organisation. Dr. Gibson's plan may seem attractive on paper, but it may be doubted, first, whether societies would combine in an appeal to the general public on behalf of scientific publications; and next, whether all societies would agree to let their publications be issued by such a central body even though they were relieved of the cost of publication. He may not know that what led to the dissolution of the Conjoint Board of Scientific Societies was really the question of Government aid to scientific societies to meet increased costs of publication. Probably a sum between 50,000*l.* and 100,000*l.* a year would be required to cover the costs of the publications of British scientific and technical societies, and experience shows that a proposal to appeal to the general public for funds to provide this amount annually would not be welcomed by some of these societies, while others would actively oppose it.

WE learn from the *Revue Française d'Ornithologie* of December, that an association formed for the protection of bird life in Belgium is about to establish an "International Experimental Station for the Protection of Birds." It would appear that this institution is to combine to a certain degree the functions of a museum, of a wild bird reserve, and of a zoological garden. In general aspect the station will resemble a private mansion, with park land, avenues of trees, thickets of undergrowth containing especially nut trees and berry-bearing bushes, and here and there sheets of water. The museum portion of the station will contain a collection of material from all countries, illustrating the various methods employed for the protection of birds in different lands, and through exhibition of these, it is hoped that public opinion may be educated towards the most efficient methods. The bird-reserve will automatically develop in the grounds of the station, as

birds, common or scarce, find that they may nest there undisturbed, and find, moreover, that they are provided with suitable food during periods of stress. Birds on the verge of extinction, or foreign birds which it seems desirable to acclimatise, will form the zoological garden side of the station's activities. A series of very large flight aviaries will be constructed, in which the birds will have every opportunity of living and feeding in as natural a manner as possible. Should this endeavour to ensure mating and successful nesting prove fruitful, the station would become a centre for the dispersal to suitable localities of species of birds which had become scarce, or of acclimatised foreign species.

THE *Times* for January 9 publishes a telegram from its correspondent in New York, announcing that one of the 25 eggs of a Deinosaur, brought from Mongolia for the American Museum of Natural History (see NATURE, December 8, 1923, p. 838, and December 22, p. 910), is to be sold by auction, the minimum bid that will be accepted being five thousand dollars. As the bids rise, they will be communicated to the persons anxious to secure the specimen, further offers being thus hoped for. The price is a serious advance on the 400*l.* originally suggested, and it may be questioned if this new method of disposing of important scientific specimens will prove welcome to the curators of public museums or to workers carrying on research. The fact that the egg is between ten and eleven million years old is stated as an attraction; but this may lead to its becoming an ornament on the breakfast-table of some multimillionaire, rather than a properly appreciated treasure in the wall-case of a public collection. It is to be hoped that the sporting proposal made by the American Museum will not check the international courtesy of presentation and exchange that has hitherto prevailed among scientific institutions.

THE address delivered by Prof. J. W. McBain, of the University of Bristol, on the occasion of his opening the Jesse Metcalf Chemical Laboratory, Brown University, is printed in *Science* of November 30. Prof. McBain dwelt on the great debt owed by industry to purely scientific investigation. He showed how the application of the laws of thermodynamics lay at the root of the Haber synthetic ammonia process, which is producing in Germany at the rate of 1000 tons a day. He pointed out, however, that it is not upon utilitarian grounds that the claims of science should be presented to an educated community—"for its pursuit the chief requirement is character." Prof. McBain believes that "a chemical department flourishes most when side by side with strong departments of all faculties. It must be filled with the spirit of humanity, its teachers with the spirit of research. They should be a body of men whose zeal for knowledge and desire to increase it are principles of life; and its teaching should be such as to fit the student to be his own teacher and to continue the study of his subject on his own account after he has taken his degree."

IT is announced in *The Monthly Summary of the League of Nations*, vol. iii. No. 11 (December 15, 1923), that a Committee of Wireless Experts, which met at Geneva on November 14 and 15 last has decided to propose to the Advisory Committee on Communications and Transit that the Council of the League of Nations shall be requested to take preliminary steps for the convocation of a conference for the purpose of drawing up international regulations applicable to all wireless communications; the idea being that the important work begun at the Conference of Wireless Experts held at Washington about a couple of years ago should be continued and further developed. It has been proposed that as large a number of States as possible should be invited to the next conference on this subject, including the United States of America.

ACCORDING to a letter from the Russo-British Chamber of Commerce appearing in the December issue of the *Decimal Educator*, the metric system will be introduced officially into Russia on January 1, 1927. Meanwhile it is being gradually introduced under the control of a special inter-departmental metrical commission. Since March 10 of last year, the manufacture, sale, and purchase of old measures and weights have been prohibited. Milk was to have been retailed in litres since January 1 last. The commission is also endeavouring to ensure that the population should be instructed in the use of the metric system, and the Tea Board has been instructed to retail tea in metric weights. Similarly, efforts are being made to introduce metric water meters, and the Customs and other State institutions have also been instructed to introduce the metric system.

A NEW expedition for the ascent of Mount Everest will leave Darjeeling towards the end of March. The staff and approximate programme are announced in the *Times*. Brigadier-General the Hon. C. G. Bruce will again command, and will have with him Major E. F. Norton as second-in-command, Mr. G. Leigh-Mallory, Mr. T. H. Somervell, Captain J. B. L. Noel, Captain G. Bruce, and Captain C. J. Morris, all of whom were with the expedition of 1922. The new members of the expedition are: Mr. N. E. Odell, Mr. B. Beetham, Mr. A. C. Irvine, Mr. J. V. Hazard, Major R. W. G. Hingston, and Mr. E. O. Shebbeare. The climbing party will consist of Major Norton, Captain Bruce, Messrs. Mallory, Somervell, Odell, Beetham, Irvine, and Hazard. Major Norton will be in command of the high camps, and the climbers will be equipped with oxygen apparatus modified in the light of the 1922 experience. Captain Noel will be the official photographer, and Major Hingston medical officer and naturalist. From Darjeeling the expedition will follow the route of 1922 and establish a base in the Rongbok valley. The attempt on the summit will be made towards the end of May.

A WIRELESS telegraph service between England and Austria was officially inaugurated on January 12, when several telegrams of congratulation passed between the two countries. The service is operated by Marconi's Wireless Telegraph Company, in conjunction with the Austrian Marconi Company. This is a direct and continuous duplex service, transmission passing from Radio House, London, through the

Marconi station at Ongar, Essex, to Laaerberg, where the messages are automatically relayed to the Central Office at Renngass 14, Vienna. Transmission from Vienna is carried on through the Deutsch-Altenburg station, and messages for Great Britain are received at the Brentwood station and automatically relayed to Radio House. The service is working efficiently, and the transmission of a message between London and Vienna takes 10-15 minutes. In view of the delays to which messages sent by wired telegraphy to Austria are subject, owing to recent storm havoc, such a rapid service is of great value. The rates charged for wireless messages between London and Vienna are for the present the same as those for landline telegraphy. A wireless service between Vienna and Berlin has also been opened, and the operations of the Austrian station will in time be extended to place Vienna in wireless communication with all the principal European cities.

THE demonstration given in the Stoll Picture Theatre (through the kindness of Sir Oswald Stoll) by the Selborne Society on January 10, in connexion with the twelfth annual Conference of Educational Associations, was intended to carry the movement in favour of the use of the kinematograph in education a step further. Many films have a general educational value; but few, if any, have been produced for actual teaching in schools; and until it is possible for schools generally to obtain projectors, there will not be sufficient demand to warrant this being done commercially. There has been much discussion on the subject, but, as Sir Sidney Low, who presided, said, while this has been going on, a few pioneers like Mr. Hodges and Capt. de Valda have picked out existing films (or parts of them) and taken them with a portable projector into the schools and given actual lessons during their ordinary hours. This is quite different from introducing films into lectures or showing them in the evening, as the Selborne Society and others have been doing for some time. Examples of lessons were given by lecturers on the Selborne Society's list who have been helping Capt. de Valda in the scheme of visual education which he has elaborated. The first was on "Volcanoes and Earthquakes," by Capt. Wilfrid Howell, and was followed by a film made of parts of several old ones. Another dealt with Lady Jane Grey, illustrated by scenes from a well-known photoplay, and was given by Mr. Percival Ashton; while the third was on "Sticklebacks," by Mr. Montagu Phillips. Sir Sidney Low pointed out that films can well illustrate the applications of science to industries. In this connexion a film showing among other things the use of the oxy-acetylene blowpipe in the shipbuilding yards of Messrs. Vickers was exhibited.

LORD CHALMERS has been elected a Trustee of the British Museum in succession to the late Sir Henry Howorth.

THE Council of the Geological Society has made the following awards:—Wollaston medal: Dr. A. Smith Woodward; Murchison medal: Dr. W. Gibson; Lyell medal: Mr. W. W. King; Wollaston fund: Dr. C. E. Tilley; Murchison fund: Dr. L. F. Spath; and Lyell fund: Mr. J. W. Tutcher and Mr. H. H. Thomas.

APPLICATIONS are invited from university graduates in medicine or science, by the Joint Board of Research for Mental Disease of the University of Birmingham and the City Asylums Committee, for a scholarship in mental diseases of the annual value of 250*l.*, tenable for one year, but renewable. The selected candidate will carry out investigations under the direction of Sir Frederick Mott. Applications, marked "Research Scholarship," with copies of not more than three testimonials, must be sent by, at latest, January 31 to the Honorary Secretary to the Joint Board of Research for Mental Science, Council House, Birmingham.

THE inaugural conference of the Society of Experimental Biology was held under the auspices of the new *British Journal of Experimental Biology* at Birkbeck College, December 21-22. Dr. E. J. Allen, Prof. Ruggles Gates and Prof. J. Barcroft officiated as chairmen at three sessions devoted to papers and discussion. The communications included a paper on "Differentiation and Redifferentiation in Animal Tissues," by Dr. T. S. P. Strangeways; "New Data on Intersexuality in Fowls," by Dr. F. A. E. Crew; "The Vasomotor Activity of Pituitary Extract throughout the Vertebrate Series," by Dr. Lancelot Hogben and Mr. W. Schlapp; "The Physiology of Reproduction in the Rabbit," Mr. J. L. Hammond and Dr. F. H. A. Marshall; "Experiments on Amphibian Growth and Metamorphosis," by Mr. Julian Huxley and others; "The Influence of Light on Tissue Respiration," Mr. Munro Fox; "The Nature of Amœboid Movement," by Mr. C. F. Pantin, and other contributions. Besides the addresses given from the chair at the opening of each session, a notable feature of the conference was the symposium on the nature of cell division, in which Messrs. H. Graham Cannon and J. Gray participated. The conference was well attended, and among those who contributed to the success of the proceedings by joining in the discussions were Profs. E. W. MacBride and D. M. S. Watson, and Messrs. Murray, Cramer, and J. T. Cunningham. Information regarding membership of the Society may be obtained from either of the joint secretaries: Prof. Ruggles Gates, King's College, London, and Dr. Lancelot Hogben, the University, Edinburgh.

A WEATHER summary for the year 1923, for the period ending December 29, is given in the *Weekly Weather Report* published by the Meteorological Office of the Air Ministry. It contains values for the several elements for each of the twelve districts into which the British Isles are divided. Temperature was in fairly good agreement with the normal, the greatest departure from the mean being a deficiency of 0·6° F. in Scotland E. and W., ranging to an excess of 0·4° F. in England E. The absolutely highest temperature in the kingdom during the year was 95° F. in the Midland Counties, and temperature fell lowest in England E. and Scotland E., where the thermometer read 12° F. The highest mean temperature was 52·1° in the Channel Islands, the next warmest was 49·6° F. in

England S.E., followed by 49·5° F. in England S.W. Rainfall was in excess of the normal both for frequency and amount in all districts except England E., where the days with rain were 4 less than the normal and the amount was 0·47 in. deficient. The greatest number of days with rain was 260 in Scotland N., the highest number in any English district being 231 in England N.W.; the smallest number was 180 in England E., and 184, which is 5 above the normal, in England S.E., embracing London. Rain was heaviest in Scotland N., where the measurement was 58·39 in., and least in England E., where the measurement was 23·43 in. In England S.E. the aggregate for the year was 29·27 in., which is 1·73 in. more than the normal. The greatest excess of rain was 9·18 in. in Scotland W. Bright sunshine was in fair agreement with the normal over the whole kingdom. In England S.E. the duration averaged 4·5 hours daily; with the exception of the Channel Islands, this was the highest in the kingdom.

IN his presidential address to Section H (Anthropology) of the British Association at Liverpool in September last, Prof. P. E. Newberry impressed upon his audience the almost unique advantages presented by Egypt as a field of anthropological study. There was a peculiar appropriateness in this plea, as the sectional meetings were being held in the Museum in which the re-arrangement of the Egyptian collections was then being completed in accordance with a typological scheme drafted by Prof. Newberry himself. It might well have served to illustrate his contention. A catalogue of the collection has just been issued. It is partly the work of Prof. Newberry and partly that of his successor in the chair of Egyptology at Liverpool, Prof. T. Eric Peet. Unlike the usual type of museum catalogue describing the exhibits case by case in order, it groups the exhibits according to their purpose, giving each its proper context and its historical setting in the life and culture of the Egyptian people, while references are given to the cases in which the exhibits will be found. The main headings of this scheme of classification are "The Arts of Life," "The Arts of Pleasure," "Science," and "Religion." Introductory chapters dealing with the geography, language, writing, and giving brief sketches of Egyptian history and the political constitution, make it possible for the collections to be used with profit as an introduction to the study of Egyptian culture as a whole. A study of Mesopotamian archæology on similar lines, so far as the material allows, would be equally interesting and even more valuable.

MR. JOHN MURRAY announces "Cancer Research at the Middlesex Hospital, 1900–1924: Retrospect and Prospect," a compilation by members of the staff of the Hospital and School, and issued by authority of the Cancer and General Research Committee. It will be in two sections dealing respectively with laboratory and clinical research in cancer.

MESSRS. MACDONALD AND EVANS announce the early publication of "Pulverised Fuel, Colloidal Fuel, Fuel Economy, and Smokeless Combustion," by L. C. Harvey, descriptive of various pulverised fuel systems, plant, and applications, giving capital costs, operating costs, and data, and containing a bibliography giving some 800 references to technical papers and articles mainly on pulverised coal.

WHAT should be an interesting and inspiring volume has been compiled by Mr. W. C. Dampier Whetham and Miss Margaret Whetham of "Readings in the Literature of Science," being extracts from the writings of men of science arranged to tell a connected story and to illustrate the development of scientific thought from the Book of Genesis to the latest revelations of the telescope and the laboratory. It will be published shortly by the Cambridge University Press.

Our Astronomical Column.

DISTRIBUTION OF TEMPERATURE IN STELLAR SPECTRA.—A circular of the Smithsonian Institution, Washington, D.C., gives a brief account of a research which Dr. C. G. Abbot has been conducting at Mount Wilson. The 100-inch reflector was used in conjunction with a Nichols radiometer to study the relative temperatures of different regions of the spectrum in stars of all types; nine stars were studied, Rigel, Vega, Sirius, Capella, Procyon, Aldebaran, Betelgeuse, Alpha Herculis, and Beta Pegasi. In spite of the resemblance of spectrum, the maximum heat in the spectrum of Vega is much nearer the violet than in that of Sirius. Rigel shows two maxima, one near the violet, the other, and larger one, close to the position in the solar type.

The apparatus is capable of measuring temperature differences of a hundred-millionth of a degree; efforts are being made to increase its sensitiveness tenfold, which would greatly increase the number of stars that could be studied.

ANNUAIRE OF THE BUREAU DES LONGITUDES.—The issue of this handy annual for 1924 is on the usual lines, and contains a vast amount of reference matter useful to the amateur astronomer and physicist. The section devoted to comets might be improved by a more critical study of the orbits printed. For example, the period given for Tuttle's comet, 12·1 years, would lead people to expect its return at the end of 1924 instead of the spring of 1926. Also the elements of Encke's comet are given for 1914, though it was seen in 1918 and 1921.

The essays are on the work of Copernicus and the distances of the stars, both by M. M. Hamy; time determination and distribution, by M. G. Bigourdan; appreciations of Abraham Breguet and Louis Favé, by M. E. Picard and M. E. Fichot.

SYDNEY ASTROGRAPHIC CATALOGUE.—The printing of the results obtained at the Australian Observatories is lamentably in arrears, owing to the difficulty in obtaining funds from the Colonial Governments. All astronomers will welcome the appearance of the first two Sydney volumes, containing the measures of plates with centres in South Declination 52°, and Right Ascension 12^h to 18^h and 18^h to 24^h respectively.

The measures give diameter of image and X, Y co-ordinates to 0·001 of a réseau interval. The Y measures on each plate are made to begin with 30, to avoid confusion between X and Y.

Research Items.

THE USE OF THE PLURAL IN POLITE ADDRESS.—An ingenious, if at first sight somewhat far-fetched, theory of the origin of the plural as used in polite or ceremonial address to a single individual is put forward by Mr. A. M. Hocart in the January issue of *Man*. He points out that though neither the Greeks nor Romans used it, it became the custom of their successors. The Fijians use it, but not the Polynesians on their right nor the Solomon Islanders on their left. The explanation offered is that it is based upon a conception of the individual as many, *i.e.* upon a belief in incarnation, and that further it is to be traced to a special form of incarnation—divine kingship. Not only are kings superiors (for whom the polite plural is originally reserved), but they are also permanent and not temporary incarnations, as in the case of the Fijian priests, to whom it is used only while they are officiating. Mr. Hocart concludes by referring to our custom of addressing the king as his Majesty, and suggests that as *majestas* is defined as "literally, of the gods," in so doing we address, not the king himself, but a divine attribute.

TIBETAN BIBLIOGRAPHY.—Much information of interest to students of Tibet and its literature has been brought together by Mr. Johan Van Manen in "A Contribution to the Bibliography of Tibet," which forms No. 8 of vol. xviii. of the Journal and Proceedings of the Asiatic Society of Bengal. At the author's request, a Tibetan friend obtained for him lists containing 219 titles of the current literature of the country. They indicate 374 volumes from twenty-one presses. Some of these titles are identical with items noted in the lists of Schmidt, Böhtlingk, and Schiefner as current among the Tibetans seventy-five years ago, suggesting that change in popular taste has not been rapid. Before proceeding to analyse these lists, Mr. Van Manen has briefly described the conditions of book-production and the book-trade in Tibet, and has made a valuable survey of our present knowledge of its literature. As is generally known, the expectations which were formed that valuable Sanscrit texts might be found extant at the opening up of Tibet have not been fulfilled. Of Tibetan literature, which is really immense, comparatively little is known. Although the two voluminous religious cyclopædias, the Tanjur and Kanjur, are well known and have been carefully studied, they constitute only a small part of the religious literature. Books in Tibet are not produced in bulk for sale, but each copy is struck off for any one who desires a copy, with the permission of the owner of the blocks, whether an individual or a monastery. The paper is often so bad and the printing so indistinct that the book is illegible, while the printers may omit twenty or thirty pages to save in time and ink on the contract. This is not necessarily material, as the book may be required, not for reading, but for purposes of worship; but it adds considerably to the difficulties of the student and bibliographer.

INHERITANCE OF MELANISM.—It has been shown in many moths that, when a melanic variety is crossed with the type, simple Mendelian inheritance results, the melanic usually being dominant. But in an interspecific cross between *Tephrosia crepuscularia* and the melanic form of *T. bistortata* the behaviour was anomalous, giving in F_2 a range of peculiar forms. Dr. Heslop Harrison has now repeated this cross with different races and a different result. The F_2 contained melanics and types, and in addition mosaics. The latter represents a new allelomorph to melanism and type. It is recessive to the former but dominant to the latter. A new germinal condition has thus arisen as a result of the disturbance involved in an interspecific cross.

FOOD PRESERVATION.—The Report of the Food Investigation Board of the Department of Scientific Research for 1922, by Mr. W. B. Hardy, contains much valuable information about the many researches now in progress, the results of which are not yet ready for publication in detail. The outstanding event of the year under review was the equipment of the Low Temperature Research Station at Cambridge. The range of subjects covered by the Report is enormous, and the document is an excellent illustration of the fundamental inter-relations of the various sciences. The results of the following investigations, among others, are discussed: The theory of the freezing of tissues, fish preservation, the autolysis of meat, conditions governing the growth of bacteria, cooling of "gas" stores, time-lag of thermometers under cold-storage conditions, thermal and other properties of ethyl chloride, cold and "gas" storage of fruit, respiration in apples, diseases of apples in storage, the chemistry of ripening in apples, hydrolysis of fats, oleic acid, formation of fat by yeasts, and the chemistry of canned fish. In all these researches substantial progress, often of great scientific and practical importance, has been made; for example, experiments on the freezing of eggs have completely upset the accepted theory of the freezing of tissues, rendering a new outlook necessary. In connexion with the "gas" storage of apples, as with certain other problems, the aid of the National Physical Laboratory has been invoked with the view of reducing the temperature of small stores during the autumn and determining the relative permeability of various wall coverings and building materials to carbon dioxide. Much light has been thrown on the diseases of apples in storage, both those of a functional nature and those caused by fungi, and the comparison of the keeping qualities of apples grown on different soils makes interesting reading. In the work on the formation of fat by yeasts, it has been shown that maltose produces a greater storage of carbohydrate than do other sugars, although it is not more effective in increasing the fat content; the maltose is apparently built up directly into a polysaccharide. In the chemistry of canned fish a new method has been devised for estimating trimethylamine, and in work on the autolysis of meat a method has been elaborated for determining small quantities of succinic acid in muscle.

THE PREDECESSORS OF LIMULUS.—Among the numerous papers issued from the Palæontological Laboratory of the Peabody Museum, Yale University, we may direct attention to the description of a new xiphosuran genus, Paleolimulus, by C. O. Dunbar, which appears under the head of "Kansas Permian Insects, part 2." The author is able to produce a good restoration from his material, and even to describe the limbs. He reviews historically the allied genera Prestwichia and Belinurus, which have special interest for workers in the British Isles, and he regards Paleolimulus — shall we write Palæolimulus?—as best representing the ancestral stock of Limulus, from which these two genera are divergent. Packard's Protolimulus from the Chemung Sandstone (uppermost Devonian) of New York (1886) is regarded as too obscure to allow of comparison; but Mr. Dunbar seems to have overlooked W. H. Baily's *Belinurus kiltorkensis* (1869) from beds of the same

age in the county of Kilkenny. New interest now becomes attached to the two imperfect specimens of this species, which were redescribed in the *Geological Magazine* for 1901 by G. A. J. Cole. Both represent the cephalothorax, and some details seem to be repeated in Paleolimulus. Now that arachnids have been described from the Middle Devonian beds at Rhynie, Dunbar's ancestral xiphosuran may not lie long concealed.

THE BASALTIC LAVAS OF HAWAII.—In a note on Prof. H. S. Washington's systematic investigation of the lavas of the Hawaiian Islands (NATURE, vol. 112, p. 521, Oct. 6, 1923) it was remarked that the prevalence of basaltic glass in the Pacific islands remained unexplained. Prof. Washington now (*Amer. Journ. Sci.*, Nov. 1923, p. 409) provides a study of the aa and pahoehoe types, and attributes the small amount of crystallisation in pahoehoe to the fact that it is erupted at a high temperature, and with little included gas, and drops rapidly in temperature, that is, in fluidity, to a condition when the viscosity does not permit of the formation of crystals. The aa, on the other hand, flows out at a lower temperature, but contains more gas, and maintains its initial temperature and fluidity for a long time, during which crystals are forming and imparting to it a stony texture, which results in the rubbly character of the surface. The final drop in temperature (fluidity) to the point where viscosity checks crystallisation, is rapid, but occurs just before consolidation.

LIME-ROCKS IN THE UNITED STATES.—The combined Reports of the Iowa Geological Survey for 1917 and 1918 (apparently published in 1923) include a memoir by F. A. Wilder on "Gypsum, its occurrence, origin, technology, and uses," extending over 500 quarto pages. The bibliography attached will be useful in technical and scientific libraries; it does not claim to be complete, but more entries might have been expected for some European countries. The records and illustrations of trials on "calcined gypsum" building materials (plaster of Paris and stucco) will be of wide interest to industrialists. Mineralogists might have liked a photograph of one of the noble crystals of selenite described by J. C. Talmage from Utah in 1893; but this would have been only accessory to a mass of practical information not easily procurable elsewhere. In Massachusetts the qualities of limestones for the production of the best lime have been investigated by the U.S. Geological Survey (Bull. 744, by T. Nelson Dale, 1923), since there has been an increasing tendency to reject dolomitic varieties, which are common in the "lime belt" of the State. Mr. Dale shows the microscopic structure of the latter in a series of neat drawings, the crystalline grains of dolomite sometimes occurring in a porphyritic fashion among smaller ones. The rocks are of Cambrian and Ordovician age, and have now been mapped in detail on a lithological basis. Coloured maps accompany the bulletin.

THE NILE FLOOD OF 1913.—The long delay in publication of this detailed report of the Nile and the rains of the Nile basin in 1913 is the outcome of War conditions. It is now published as Paper No. 12 of the Physical Dept. of the Ministry of Public Works, Cairo. The flood of 1913 was one of the poorest on record, and was late in starting; the tributaries affected by spring rains were low when the flood began. At Halfa the flood maximum was 5·97 metres compared with 6·92 metres in 1899, which was the previous lowest maximum since 1890. The principal rains of the Nile basin from June to September 1913 were deficient in every district except the lake plateau of Tanganyika Territory. The average deficiency was 5·26 per cent., and the Abyssinian rainfall was 37 per cent. less than normal. The rains of September to December in Uganda and the lake plateau were also less than the mean. Dr. H. E. Hurst, the author of the report, has not, however, found any close connexion between the rains of Tanganyika and those which cause the Nile flood. Full details of rainfall and river gauge readings for the year are given.

CANADIAN TIDAL STATIONS.—In a complete tidal survey in waters with a great variety of types of tide, as the coasts of Canada, a few principal stations are required to which the tide in the various harbours is referred, as well as the time at which the tidal streams turn. Dr. W. B. Dawson, in a paper on principal and secondary tidal stations (Transactions Royal Society of Canada, xvii. p. 43), points out the value of reducing to the fewest possible the number of these reference stations. In the Canadian tidal survey which began in 1894 there was a clear field and the stations were established at strictly strategic points on open coasts and away from local influences. For the St. Lawrence estuary the two principal reference stations are at Father Point and on St. Paul Island in Cabot Strait. The open Atlantic coast is referred to Halifax, N.S., and the Bay of Fundy to St. John, N.B. The whole of the open Pacific coast is covered by two stations; one at Clayoquot on Vancouver Island and the other at Port Simpson. For places in the Strait of Georgia there is a reference station at the mouth of the Fraser River. In Hudson Strait it was found that the tides could be referred to St. John, N.B., while in Hudson and James Bay the tides proved to be similar to those of the North Sea, enabling Harwich and Bremerhaven to be used as reference stations.

WEATHER IN WEST INDIES.—Summaries for each month and for the year, giving climatological data for the West Indies and Caribbean Service, are regularly received from San Juan, Porto Rico, prepared by Mr. Oliver L. Fassig, Meteorologist in charge, and published by the U.S. Department of Agriculture. Returns are received to February of the past year; the annual summary for 1922 states that daily rainfall returns were received during the year from about 500 stations, distributed over the West Indies, the north coast of South America, Panama, and the Yucatan Peninsula. Rainfall for the area as a whole was decidedly deficient, and precipitation for 1921 was also less than the normal for 20 years, aggregating for the year a deficiency of 7·59 in. and in 1922 a deficiency of 7·79 in., the deficiency in both years being greatest in the summer and autumn months. In the two years there was a deficiency during 17 months, aggregating 20·65 in., and an excess in 7 months, with an aggregate excess of 5·27 in. In 1922 rainfall was deficient over practically the entire area from April to July. Air temperature for 1922 was above the normal in most parts of the area, but was well below the normal in Porto Rico, the Virgin Islands, and Turks Island, as well as along the coast of Central America. Two destructive hurricanes were experienced, one in the middle of September and the other in the middle of October, while four additional cyclonic disturbances of minor intensity originated over the Western Caribbean. The heaviest annual rainfall in 1922 at any station was 359·10 in. at Lakeside (Dominica), followed by 209·81 in. at Fellowship (Jamaica), while there are several stations with more than 100 in. The least annual fall is

4·32 in. at Palm Grove (Turks and Caicos Islands); there is no other station with less than 10 in. and there are fewer than 20 stations with so little as 20 in. In 26 months ending February last, precipitation was below the normal in 19 months and above in only 7 months.

TOTAL REFLECTION OF X-RAYS.—A series of photographs of total reflections of X-rays from surfaces of lead and platinised glass have been received from Prof. Paul Kirkpatrick, of the University of Hawaii, Honolulu, together with a description of the experiments in which they were produced. Somewhat similar reflections from the surfaces of glass, silver, and lacquer have already been described by Dr. Arthur Compton, but this appears to be the first time that totally reflected X-rays have been photographically recorded. Four of the photographs were from plate glass sputtered over with an almost opaque layer of platinum, and show strongly as a straight line the photographic effect of the undeflected, directly transmitted X-ray pencil, and at some little distance from it, and more or less parallel, the fainter effect of the reflected rays. The other three photographs were from reflectors made by pressing clean lead surfaces against plate glass, and show similar but not such sharp effects. Unfortunately the photographs cannot with advantage be reproduced as an illustration. The results show that the reflection was correctly specular within the observational limits. The reflections from the lead surfaces were much more diffuse than those from platinised glass, probably because of less perfect planeness of the lead mirrors. The faintness of the reflected image compared with the direct transmitted one indicates that the so-called total reflection is really far from total, but the intensity increased as the glancing angle diminished. The X-rays used were of the region of the K-lines from a tungsten source, and in some of the photographs discontinuities are observed corresponding to specific characteristic K-radiations of known wave-length. Prof. Kirkpatrick suggests from this fact the possibility of using this X-ray total reflection effect as a means of measuring wave-lengths. For wave-lengths not too long the following formula holds:

$$\lambda = 431 \sqrt{w/\mathrm{DZ}} \sin \theta$$

in which D, Z, and w represent respectively the density, atomic number, and atomic weight of the reflector, and the wave-length λ is in Ångström units.

EFFECTS OF IMPURITIES IN CATALYSTS.—In the process of addition of hydrogen to organic compounds in the presence of catalysts, it is known that the final product may be modified by the temperature of the reaction, the nature of the catalyst, and impurities present in the latter. An interesting example of the effect of impurities in the catalyst is described by M. Faillebin in the *Comptes rendus* of the Paris Academy of Sciences (Nov. 26, p. 1118). Ethyl acetoacetate is reduced by hydrogen in the presence of pure platinum black to ethyl butyrate (80 per cent.) and ethyl β-oxybutyrate (20 per cent.); if the platinum black contains iron as impurity, only the latter substance is produced. It is shown that the ethyl β-oxybutyrate is not formed as an intermediate reduction product, since it was found that this is not reduced by hydrogen in the presence of pure platinum black. The same change in reducing power is noted when iron is replaced by aluminium as the impurity. Other ketones show similar differences on reduction with pure and impure catalyst.

PHOTOLUMINESCENCE OF DYESTUFFS IN VISCOUS MEDIA.—The polarisation of fluorescent light from dyestuffs dissolved in viscous fluids was discovered by Weigert in 1920; and the phenomenon has recently been further investigated by A. Carrelli and P. Pringsheim (*Zeitschrift für Physik*, October 27, 1923). Eosine, safranine, uranine, and methyl violet in gelatin, when excited with polarised light, show polarised fluorescence and phosphorescence, though methyl violet is not photoluminescent in a non-viscous fluid, such as water or alcohol. The latter does not fluoresce in fluid collodion, which is an emulsion of collodion in alcohol or ether; even eosine and uranine, dissolved in such an emulsion, with a viscosity higher than that of glycerine, show little polarisation of the fluorescent light emitted; if, however, the solvent is evaporated, strong polarisation appears. The effects in glycerine are diminished at high temperatures, apparently owing to reduced viscosity; and the authors have found, first, that methyl alcohol shows strong fluorescence and phosphorescence in alcohol at −180° C., and second, that the phosphorescent light from eosine in gelatin does not always show polarisation when the gelatin strip is cooled to −185° C. The fluorescence of uranium and didymium glass, of the Lenard phosphores, the so-called "progressive" phosphorescence, which shows special spectral characteristics, with many lines, and the analogous phosphorescence of Tiede's boric acid phosphores, and similar substances, are all unpolarised. In the cases where the phosphorescence of a dyestuff is polarised, it seems probable that the molecules are anisotropic, and that polarised light is chiefly absorbed by those which happen to be oriented in a certain manner; if, in consequence of the viscosity or toughness of the solvent, the mobility of the molecules is small, the majority of those which, later on, emit light, will be similarly oriented, and the phosphorescent light will be partly polarised.

AERO ENGINES.—An interesting discussion on water-cooled aero engines is given in a paper read recently by Mr. A. J. Rowledge before the Institution of Automobile Engineers. Since the early days of flying, both water-cooled and air-cooled engines have been used, and it is probable that both types will continue to be used, since neither has reached the limit of its possible development. With water cooling the temperature of the engine is under better control to meet the great variations of temperature met with in flying at different altitudes; the problem of heating the mixture pipes and the carburettor is also considerably simplified. When the radiator and water are taken into account, the total weight of the water-cooled engine is greater than that of an air-cooled engine, but the former gives rather more power for the same cylinder capacity, and at a less expenditure of fuel. The provision of a variable-pitch airscrew, or the alternative of a variable-speed gear, is a subject worth investigating and is bound to have a great effect on the type of engine. Engine builders in the past have usually left the airscrew to the aeroplane designer, and it appears to be unfortunate that the variable-pitch airscrew has not made more rapid progress. A complete set of regulations for aero engines should be drawn up by machine designers; these would be of value to engine designers when deciding their programme of future development without any competition taking place. A number of power plants each complete in itself and placed in suitable positions are more likely to be successful in providing maximum freedom from engine breakdown without sacrificing efficiency than the provision of central engine-room arrangements.

Geographical Instruction and British Climate.

THE annual meetings of the Geographical Association were held in Birkbeck College, London, on Jan. 2-4. They were remarkable chiefly for evidences of new experiments in co-operation of varied character. Closer contact with the business world was sought through the conference on railway geography, presided over by Mr. R. Bell, Assistant General Manager of the L.N.E. Railway, well known for his up-to-date educational policy. It may not be generally known that for some years this railway company has arranged for courses of instruction in geography to be given to railway men. The scheme has proved of sound business value, and it is to be hoped that other commercial firms in Britain will realise what commercial firms in America have long known, namely, the importance of a knowledge of geography in an up-to-date business education. Mr. Llewelyn Rodwell-Jones, lecturer in economic geography in the University of London, and Mr. C. B. Fawcett, reader in geography in the University of Leeds, each of whom has had experience in conducting classes for railway men, opened the discussion with very able papers. They dealt with the sort of geography which helps the railway man, and also with the help which railways and a study of them may be to the geographer. The interesting questions of the railway called into being by the town, and the towns, and especially the modern garden city, made possible by the railway, were discussed with concrete examples.

Another attempt at co-operation of a different sort was the invitation extended to, and accepted by, Prof. Em. de Martonne, professor of geography in the University of Paris, to address the Association. His subject was Transylvania, and it was studied in a masterly and logical way on the basis of the regional method so characteristic of the French school of geographers. The illustrations were remarkably clear and apposite, and the audience obviously appreciated the lecturer's logical presentation of his subject.

Co-operation with British colonies was represented by the address of Mr. L. MacD. Robison, of Colombo, Ceylon. The numerous facts brought out as a result of the lecturer's personal experience in Ceylon showed that generalisations about climate, productions, and population are often dangerous to the best scientific interests of geography. Each region must be carefully studied from observation and actual contact, and not merely classed as a unit in a large and abstract study. Diversity in reality, and unity in theory only, seems to be the rule for geographers as well as for anthropologists. Mr. Robison sounded an important cautionary note against too readily taking for granted that pictures and lantern slides really showed the things they claimed to show.

Co-operation of still another type was attempted by arranging a joint meeting between meteorologists, science teachers, and geographers. As Mr. G. M. B. Dobson, reader in meteorology in the University of Oxford, ably showed, meteorology has made extraordinary advances in the last quarter of a century, both in method in and increase of understanding of the laws that govern weather conditions. The presence in the chair of Sir Napier Shaw, who has destroyed many preconceived notions of the causes of meteorological phenomena, emphasised Mr. Dobson's remarks. Mr. L. B. Cundall dealt with practical teaching problems, such as the use of home-made apparatus, and the inclusion of meteorology in the geographical curriculum rather than its introduction as a separate subject. Mr. W. G. W. Mitchell gave an analysis of the wireless information available for the preparation of weather charts in schools, namely: (1) the 10.5 A.M. daily message from Paris sent on 2600 metres spark and giving observations for about 60 European stations; (2) the synoptic data message for the British Isles and Iceland, comprising about 30 stations, and sent out by the Air Ministry on 4100 metres continuous wave at 2 P.M. daily; (3) international collective messages from the Air Ministry at 8.50 A.M. and 2.50 P.M. on the same wavelength; (4) shipping bulletins from the Air Ministry at 9 A.M. giving particulars from ten coastal observing stations, with a general inference of weather conditions over N.W. Europe and adjacent seas. He considered these the four most useful messages to be selected by teachers. Mr. Mitchell also illustrated, obviously from his own experience at Newbury Grammar School, the use which might be made by agriculturists of the information which their sons could thus collect in school. Certainly schools in which meteorology is studied in this way do not lay themselves open to the complaint that science teaching in school has no bearing on practical affairs in everyday life.

In his presidential address on "British Climate in Historic Times," Sir Richard Gregory brought together much statistical material as well as interesting literary references concerning rainfall and temperature in Britain, particularly in the London area, from the time of the Venerable Bede (672-735) to the present epoch. The chief literary sources used were the "Anglo-Saxon Chronicle," the "Chronica Majora" of Matthew Paris, John of Oxenden's "Chronicle," William Merle's "Consideraciones Temperiei"—the first actual journal of the weather in England—John Locke's register of the weather given in Robert Boyle's Collected Works, the Diaries of Evelyn and Pepys, Gilbert White's "Selborne," and Horace Walpole's "Letters."

In all early records there are frequent references to unseasonable weather, severe frosts, great storms, thunder and lightning, and so on, but no more than would be set down by an observer in our own times. Heavy storms and exceptional weather occurred much the same as now in different years and at different times of the year, but as the people were formerly directly dependent upon the "earth-fruits" of their districts they naturally gave chief attention to weather which reduced or destroyed their means of existence. The year 1594, which was unusually wet and unseasonable, is of particular historic interest because its rains and floods are believed to have been in Shakespeare's mind when writing "A Midsummer-Night's Dream," in Scene 1 of Act II. of which Titania describes the bad weather provoked by fairy brawls and says that

> Through this distemperature we see
> The seasons alter: hoary-headed frosts
> Fall in the fresh lap of the crimson rose,
> And on old Hiems' thin and icy crown
> An odorous chaplet of sweet summer buds
> Is, as in mockery, set. The spring, the summer,
> The childing autumn, angry winter, change
> Their wonted liveries, and the mazed world,
> By their increase, now knows not which is which.

More than three centuries ago, therefore, Shakespeare expressed the same view as to change of seasons or climate as that commonly held at the present time.

In the eighteenth century general observations relating to weather cease to be of meteorological interest, because instrumental records then began to be kept continuously. Records of the mean annual

rainfall in London exist since 1774, and they show that the maximum value was 35·54 in. in 1903, and the minimum 12·50 in. in 1921. Taking groups of 10 years there were periods of general deficiency from 1780 to 1809, 1850 to 1859, 1890 to 1909, and 1920–1922, while periods of general excess were 1810 to 1849, 1860 to 1889, and 1910 to 1919. Of course, no real importance can be attached to these particular groups of ten years, and individual years in them are much above or below the average, yet the numbers show no continuous change either one way or another. The relatively dry period which began in 1919 was preceded by four years in each of which the rainfall was well above the average, and the excess for the 10 years 1910–19 was much greater than for any of the other ten-year groups since 1780.

The association of snow with Christmas, common in Christmas stories and almost an essential feature of Christmas cards, is one for which little meteorological evidence exists so far as London and the neighbourhood is concerned. In the period of eighty-three years since 1840, snow has been recorded on Christmas Eve at the Royal Observatory, Greenwich, on two occasions only, namely, 1846 and 1849. There are only six years in which snow has fallen on Christmas Day and ten on Boxing Day. Grouping all three days together, the chances against snow in and near London are nearly five to one, or taking Christmas Eve and Christmas Day together, not in one year in ten has a fall of snow been recorded. The snowy Christmases of imaginative writers and artists have thus now but rare existence in the south of England.

It must be remembered, however, that, on account of the change from the Julian to the Gregorian calendar in 1752, Christmas Day now occurs eleven days earlier than it did. Records of the mean air temperature for 24 hours of Christmas Day in London since 1814 show that, in these 109 years, there were only 23 years in which the mean temperature was at freezing point or below. The lowest mean temperature was 18·6° F. in 1830, and the next 19° F. in 1860 and 1870. There are only three periods in which three or more successive Christmas Days had a mean temperature at freezing point or below, namely—1814–20, 1829–31, and 1890–92. Not for a single Christmas Day since 1892 has the mean temperature in London been down to 32° F., and in this 30 years the minimum temperature has only been at freezing point or below in 10 years—one year in three. The highest mean temperatures on Christmas Day were 1824, 53·1° F.; 1837, 51·5° F.; 1852, 50·7° F.; and 1920, 50·6 F. Though mild and severe Christmases have occurred at irregular intervals since 1814, there has not been such an unbroken series of Christmas Days with a mean temperature above freezing point as that recorded since 1892 in London.

The origin of the belief in a progressive and permanent change of climate in historic times is probably to be found in the fact that temperature and rainfall everywhere have a tendency to vary in a period having an average length of thirty-five years. This cycle was referred to by Francis Bacon in his essay "Of Vicissitude of Things," and was worked out in detail by Prof. E. Brückner some years ago. Neglecting individual years, it may be stated that for about half this period of about thirty-five years the weather is warmer and drier than the average, and for the other half colder and wetter. The groups of years for which Brückner found clear evidence of these characteristics are as follows:

Warm.	Dry.	Cold.	Wet.
1746–1755	1756–1770	1731–1745	1736–1755
1791–1805	1781–1805	1756–1790	1771–1780
1821–1835	1826–1840	1806–1820	1806–1825
1851–1870	1856–1870	1836–1850	1841–1855
..	..	1871–1885	1871–1885

It will be noticed that the interval from the beginning or end of one period to the beginning or end of the next of the same kind varies from twenty to fifty years, but the average is about thirty-five years. The series of wet years which culminated in the black year of 1879, memorable to all who were then engaged in agriculture, was matched by the wet period of 1910–1918. If the cycle holds good we may expect that, on the average, the weather will be warmer and drier than usual for a few years, but any single year may depart from this rough generalisation.

Records of the mean annual temperature for various meteorological districts in Great Britain from 1878 to 1920 show that, while the lowest values occurred in most districts in 1879, the highest were mostly in 1898, thus following the order of Brückner's cycle. Taking the districts as a whole, the greatest deviation from the normal was −2·3° F. in 1879 and +1·6° F. in 1898.

Sir Richard Gregory concluded from this and other evidence surveyed in his address that, while there have been abnormal periods of British weather in historic times, there is no decided indication of progressive change either for the better or worse, and that no cycle of practical service can be said to be established, though several of academic interest seem to exist.

The Chemical Composition of the Prehistoric Bronzes.[1]

By Prof. JOHN SEBELIEN, Norwegian Agricultural Institute, Aas, Norway.

IN a paper read a year ago before the Scientific Society at Christiania, I discussed the old doubts of the greater age of bronze in comparison with iron. The relative slight reducibility of the oxidised iron ores, and the difficulty of the preparation of metallic copper from its most common (sulphuretted) ores, as well as the high degree of human civilisation required for making an alloy such as bronze, are circumstances weighing very heavily in favour of the greater antiquity of the Iron Age. Nevertheless, the paradoxical nature of the theory of the greater antiquity of the Bronze Age is somewhat mitigated by recent researches.

It is now admitted by leading archæologists that metallic iron certainly was *known* a long time before bronze to the old Egyptians, but only as a curiosity for jewellery and decoration purposes (as beads), and not as a metal in common use. Also, it is generally assumed that in many countries a period with pure copper as a commonly used metal preceded the Bronze Age. A Copper Age is generally shown in Central Europe, and even in Northern Europe it is shown that the Stone Age of Sweden and Denmark was followed directly by a Copper Age. Norway, however, seems to be an exception to this. I have analysed samples from all the very oldest findings from the Norwegian Bronze Age, among them a piece of a metal looking like copper from an old Stone Age place, but they were all real tin-bronzes.

[1] Substance of a paper read before Section H (Anthropology) at the Liverpool meeting of the British Association.

Even in England, according to Sir Hercules Read, there has not been a pure Copper Age, but the bronze must have been made directly from the copper ores containing tin. Similarly, we find antique Roman brass implements many centuries before the isolation of the metallic zinc.

Of special interest are the old metallic objects from Egypt and Mesopotamia, the cradle of the culture. M. Berthelot has shown that the old bronze objects from these countries contained no tin, but consisted of pure copper. I lately had the opportunity, through the kindness of Sir Flinders Petrie, of analysing 29 samples from old Egyptian objects, with the result that 24 of them, among the very oldest, belonging to the earliest dynasties, were practically pure copper without any trace of tin. The accessory impurities were mostly traces of iron, zinc, nickel, arsenic, lead, but never antimony. In some cases there were very small traces of silver or bismuth. Objects from a later period were real tin-bronzes of normal composition, and might contain traces of antimony besides the arsenic.

Most of the old Egyptian copper no doubt came from Sinai, and there is a good accordance between the impurities we have found in the copper objects and the accessory metals in a slag from Sinai. But other copper objects, *e.g.* those containing traces of silver and bismuth, must have another origin. An old metallic nail of Sumerian age in Mesopotamia was practically pure copper also, but an X-ray spectrogram showed a trace of cobalt, besides traces of nickel, iron, lead, and arsenic.

The bronze bands from the gates of the palace of Shalmanesir II., now in the British Museum, belong to a much more recent period. Through the kindness of Sir Ernest Wallis Budge, I obtained a sample for analysis from these bands. They are real tin-bronzes with about 9 per cent. tin, and here, too, the X-ray spectrogram showed a trace of cobalt besides the traces of nickel, iron, lead, and arsenic. It is not unreasonable to assume that even the old Chaldæans obtained their copper from the ores of Sinai. But the presence of cobalt in both the objects from Mesopotamia is not in accord with the definite absence of the same substance from any of the old Egyptian objects analysed. We have been unable to get a sample of the original ore from the Sinai mines.

We have, however, obtained a sample of a very old copper ore, that possibly may have been used for Mesopotamian copper and bronze objects. It is from an old mine in Kurdistan. By X-ray spectrographic analysis, it was found that it contained, besides copper, the accessory metals zinc, iron, lead, and arsenic, and not insignificant quantities of cobalt and, furthermore, manganese, but no nickel. The presence of cobalt would be in good accord with the result of the analyses of the Mesopotamian objects, but the complete absence of nickel prevents us from assuming a connexion between the Kurdistan ore and the metallic objects from Mesopotamia.

Paris Academy of Sciences.

LOUTREUIL FOUNDATION.

FORTY-ONE requests for grants were received and the following twenty-seven grants were approved:

I. Grants made at the request of establishments named by the founder:

(1) Muséum national d'histoire naturelle: 10,000 francs to Pierre Teilhard de Chardin for the exploration from the geological and palæontological point of view of the regions which extend to the borders of Mongolia.

(2) Conseil central des Observatoires: 3000 francs to Armand Lambert for assistance in printing the catalogue of fundamental stars of the Paris Observatory.

(3) École nationale vétérinaire d'Alfort: 3000 francs to François Maignon for the continuation of his researches on the physico-chemical constitution of the diastases (biological catalysts) and the mechanism of their action; 850 francs to P. Dechambre for the purchase of an apparatus designed for the study of wool; 3000 francs to André Delmer for researches relating to the physiology of the breast; 3000 francs to Adrien Panisset and Jean Verge for the continuation of the researches which they have undertaken on the chemicotherapy of infectious diseases of animals; 5000 francs to Émile Nicolas for the purchase of a centrifuge.

(4) École national vétérinaire de Lyon: 2000 francs to Prof. Douville to continue his researches on the etiology of distemper and other canine diseases, and for the purchase of apparatus for ultra-microscope work; 2000 francs to G. Marotel for the continuation of his researches on parasitic diseases of domestic animals; 4000 francs to Joseph Bassett to complete his researches on typhoid fever of the horse; 2000 francs to L. Jung to continue his researches on the transformations of food albumins in the organism, particularly their rôle in fat formation; on the chemical function of mixed saliva in different species and on the origin of salivary amylase and the possible factors of its activation.

(5) École nationale vétérinaire de Toulouse; 3000 francs to Albert Daille for research on a preventive and curative serum against epizootic diarrhœa in newly born calves; 500 francs to Charles Hervieux for a study of intestinal putrefaction and coprology; 1500 francs to Clément Bressou for researches on the lymphatic system of domestic animals.

II. Independent requests: 2500 francs to Henri Colin for the purchase of a Bruhat apparatus and its accessories, especially a mercury vapour lamp, for his researches on the hydrolysis of the carbohydrates; 5000 francs to the Comité de la Carte géologique d'Afrique (secretary, Emanuel de Margerie) for the purposes of this map; 4000 francs to Gaston Fayet for printing the catalogue of intermediate stars of the Nice Observatory; 10,000 francs to the Fédération Française des Sociétés de Sciences Naturelles for the publication of the fauna of France; 6000 francs to Edmond Friedel for his work on the diffraction of X-rays; 10,000 francs to Guillaume Grandidier for completing the printing of the fourth and last volume of the "Ethnographie de Madagascar"; and for continuing the publication of the "Histoire de Madagascar"; 2000 francs to Benjamin Jekhowsky for the "Études des clichés de l'Observatoire d'Alger, au point de vue de la recherche des petites planètes"; 10,000 francs to the Laboratoire Central d'Électricité de Paris for its researches on the international ohm standards; 10,000 francs to Charles Marie, general secretary of the "Tables annuelles de constants et données numériques de chimie, de physique et de technologie," for this publication; 5000 francs to the Office Central de Chauffe Rationnelle for the study of the measurement of high temperatures in industry and the improvement of the instruments employed in practice; 8000 francs to Georges Perrier for collating the work of astronomical and geodetic order, carried out by the Equator expedition; 1000 francs to Claude Pierre for completion of a monograph on the Tipulidæ of France; 4000 francs to Joseph Jean Rey, for his researches on radiogonometry.

In all, the grants recommended amount to 120,350 francs.

University and Educational Intelligence.

LIVERPOOL.—A grant of 100*l.* from the Darwin fund has been made by the Royal Society to Dr. Margery Knight, of the Hartley Botanical Laboratories, for research on marine Algæ at the Port Erin Marine Biological Station.

LONDON.—King's College has arranged a number of attractive courses of free public lectures for the Lent term. Among them are the following: "What the Voice Looks Like" and "The Psych-analysis of the Poet," by Prof. E. W. Scripture, on February 14 and 21; "The Transition to the Relativist Conception of Nature," by Prof. H. Wildon Carr, on February 5, 12, 19, and 26; "The Possibility of Metaphysics," by Prof. Hans Driesch, on March 12, 14, 18, and 19; "Food and why we require it," by Dr. J. A. Hewitt, on January 18, 25, February 1 and 8; "Some Work in Palæontology bearing on Evolution," by Dr. W. D. Lang, on February 1 and 8; "The Internal Constitution of the Earth," by Dr. H. Lamb, on February 15, 22, and 29. Dr. Lang's lectures are at 5 P.M., and the remainder at 5.30 P.M.

University College has also arranged public lectures, among which we notice the following: "The Influence of Improved Town Planning and Housing in Public Health," by Prof. J. Robertson, on January 18, February 1 and 15, at 5 P.M.; "The Mammalian Sex-Ratio," by Dr. A. S. Parkes, six lectures commencing on January 28 at 5.15 P.M.; "Auditorium Acoustics," by Mr. G. A. Sutherland, on January 29, at 5.30 P.M.; "Psychology and Medicine," by Dr. Bernard Hart, on February 8, at 5.15 P.M.; "The Current Work of the Biometric and Eugenics Laboratories," by Prof. Karl Pearson and his staff, seven lectures commencing on February 13, at 6 P.M.; "The Origin of the Vertebrate Skeleton," by Prof. J. W. van Wijhe, on March 11 and 13, at 5.30 P.M.; "Galileo Galilei," by Signor C. Pellizzi, on March 13, at 5.30 P.M.

Some further courses of free public lectures are: "Respiratory Exchanges," by Prof. Winifred C. Cullis, at the London (R.F.H.) School of Medicine for Women, at 5 o'clock on January 24 and 31 and February 7 and 14; "The Transpiration Stream," by Prof. H. H. Dixon, at the Imperial College—Royal School of Mines (Metallurgy Department), at 5.15 on January 28, 29, and 30; "The Geography of the United States, Regional and National," by Prof. A. P. Brigham, at the London School of Economics, at 5 o'clock on February 22, 26, and 29; "Cancer," by Dr. J. A. Murray, at St. Thomas's Hospital, at 5 o'clock on February 21 and 28, March 6 and 13; "Blood," by Prof. J. B. Collingwood, at St. Mary's Hospital Medical School, at 5 o'clock on February 21 and 28, March 6 and 13.

The following doctorates have been awarded: *Ph.D.* (*Science*)—Mr. D. T. Gibson (King's College) for a thesis entitled "(*a*) Constitution of α-disulphoxides; (*b*) Some derivatives of orthohydroxy mercaptans"; Mr. J. Reid (King's College) for a thesis entitled "The isomeric 6–6′ dibromo-β-naphthol d-sulphides and the 3–3′ dibromo-β-naphthol sulphides"; Mr. A. Taffel (University College) for a thesis entitled "Thermal expansion and other volume relations of gelatin gels"; Mr. W. E. Downey (Imperial College—Royal College of Science) for a thesis entitled "The Oxidation of Phosphorus—its Luminescence and the Production of Ozone"; and Mr. R. R. Le G. Worsley (Imperial College—Royal College of Science) for a thesis entitled "The Preparation and Properties of Selenium Trioxide."

DR. GANESH PRASAD, formerly Dean of the Faculty of Science in the Benares Hindu University, has been appointed Hardinge professor of higher mathematics in the University of Calcutta in succession to Prof. C. E. Cullis.

THE Royal Sanitary Institute is organising courses of lectures intended mainly for students intending to undertake public health work. A free public introductory lecture will be delivered on January 28 by Dr. Charles Porter. The lectures to be given in the various courses include such topics as statistics, methods of disinfection, ventilation and warming, sewage disposal and water supply. Particulars of the courses and of the examinations conducted by the Institute can be obtained from the secretary of the Royal Sanitary Institute, 90 Buckingham Palace Road, London, S.W.1.

THAT American education may be regarded as a laboratory in which educational experiments are being tried on a great scale has long been recognised. Since the War, the scientific study of education in the United States has been pursued with unexampled enthusiasm, and students of the subject are being attracted from other countries in increasingly large numbers. In the Teachers' College of Columbia University, New York, there are 250-300 foreign students each year. The newly-founded International Institute financed by Mr. J. D. Rockefeller, which forms an integral part of the College, will enable such students "not only to appreciate and evaluate American and other educational systems, but also to exercise discriminating judgment rather than the imitative instinct in applying modern scientific principles to their own particular sphere of professional service." Among the Institute's courses announced for 1923–24 are: "American institutions and ideals," by Prof. Duggan; "Democracy and education in Europe," by Prof. Kandel; "Education and nationalism: the development of retarded national cultures through education," by Prof. Monroe—with special reference to the Philippines, China, the Balkans, and certain colonial possessions of European powers; "Rural and village education for students from foreign lands," by Profs. Dunn and Carney, and "Problems in missionary education," by Dr. Sailer.

THE Bureau of Education, India, has issued, as Occasional Report No. 11, a report on the preparation and supervision of rural school teachers in the United States, with special reference to the applicability to Indian conditions of some of the lessons of American experience. Chief among these is that, if the rural school curriculum is to be suited to the requirements of the child's daily life and the villager to be interested in the village school, the teacher must receive a preparation different from, but in no way inferior to, that provided for teachers of urban schools. At present village children in India "attend schools more because they are *not* interested in rural things than because they are; they are taught by teachers not prepared for distinctively rural teaching, and those who prepare teachers for rural schools have themselves, from their earliest school days, been weaned by education in schools with an urban bias from any rural inclinations they may have started with." As the future prosperity of India largely depends on the welfare of the rural population it is a matter of primary importance to break this vicious circle. Another reform urgently needed in India is the establishment of a service of rural school "supervisors" or "helpers," as they are sometimes called in America, whose chief, if not only, duties are to help and encourage village teachers, who at present, working in isolation, have but little incentive for maintaining or improving their professional efficiency, and to cultivate mutually helpful relations between the school and the local community, relating and adapting the teaching to the community's life.

Societies and Academies.

SHEFFIELD.

Society of Glass Technology, December 12.—V. **Stott**: An apparatus for calibrating burette tubes. Successive quantities of water are transferred from the blank burette tube to a standard pipette. A piece of thermometer tubing is attached to the top of the burette tube by means of two pieces of rubber tubing, and an adapter controls the rate at which air enters the top of the burette tube and therefore the rate of outflow of water.—E. **Farmer**: Some factors affecting efficiency in the glass trade. The hourly output of the eight-hour shifts is practically in all cases greater than that of the ten-hour shift. The increase is more marked in the case of larger bottles than in the case of small bottles. The morning shift is always the least efficient throughout the year. The effect of rest pauses is well known, but all stoppages of work are not so beneficial. The effect of stoppages due to the coal strike and the influenza epidemic was to lower efficiency, owing to loss of motor dexterity on the part of the workers.—W. E. S. **Turner**: Specifications in the glass industry, with special reference to soda-lime glasses for glass containers. For glass containers, there are two essentials: (i.) durability, and (ii.) a satisfactory state of annealing. Glass for common containers should contain not more than 18 per cent. of sodium oxide in the finished glass, and not less than 8 per cent. of lime and calcium oxide. The conditions for annealing vary with the composition of the glass and cannot be specified. There are definite methods of testing glassware for strain so that manufacturers and users can exercise control over their products or purchases. Specifications must have reference in every class of glassware to the conditions of use, and suitable tests or specifications were suggested.

PARIS.

Academy of Sciences, December 26.—M. Albin Haller in the chair.—M. **d'Arsonval**: Attempts at 1,000,000 volts at the Ampère Laboratory. A description of the construction and equipment of a new electrical laboratory at Paris. The three transformers employed used singly give 125 kilovolt-amperes at 375,000 volts, and can be arranged to give 1,000,000 volts or a triphase current of 660,000 volts between the phases.—Henri **Jumelle**: The Cytinus of Madagascar. Two species of this curious genus of parasitic Phanerogams are already known in Madagascar: a detailed description of a third species discovered by Perrier de la Bâthie in 1922 is given (*Cytinus glandulosus*).—P. **Lasareff**: The velocity of photochemical reactions under the action of a light of periodic intensity. It is shown that Talbot's law can be deduced mathematically from the equation of photochemical kinetics, and that this law ought to hold if the periods of light are infinitely small (or in practice, very small).—André **Job** and René **Reich**: The fixing of unsaturated molecules by metals derived from their organic derivatives. An etherial solution of $C_6H_5.MgBr$, diluted with benzene and shaken with dry $NiCl_2$, gives a solution containing nickel in a very active form. In four hours this solution absorbs the theoretical quantity of carbon monoxide required to form nickel carbonyl. The method is being applied to the preparation of other metal carbonyls, especially chromium carbonyl. Gases other than carbon monoxide, such as nitric oxide, ethylene, acetylene, also react with the above solution.—A. **Gascard** and G. **Damoy**: The alcohols and hydrocarbons of beeswax. Four alcohols were isolated in the pure state, $C_{25}H_{52}O$, $C_{27}H_{56}O$, $C_{29}H_{60}O$, and $C_{31}H_{64}O$, and four hydrocarbons, $C_{25}H_{52}$, $C_{27}H_{56}$, $C_{29}H_{60}$, and $C_{31}H_{64}$. It is interesting to note that in all the acids, alcohols, and hydrocarbons isolated from beeswax, there is an odd number of carbon atoms in the molecule.—A. **Bouzat** and L. **Azinières**: The experimental determination of the composition of the hydrate of chlorine. From the experiments described it is concluded that the formula of chlorine hydrate is $Cl_2.6H_2O$, as predicted by Villard.—M. **Allemand-Martin**: The Quaternary of the Cape Bon peninsula (Tunis).—Lucien **Daniel**: Heredity of an acquired character by grafting in the Jerusalem artichoke. Some results obtained by grafting the artichoke on the sunflower.

PERTH, W.A.

Royal Society of Western Australia, May 8.—Mr. E. de C. Clarke, president, in the chair.—J. **Clark**: Australian Formicidæ. Several new species of Phyracaces are described, and it is claimed that a revision of the classification of the family Cerapachyinæ will be necessary in view of the fresh facts disclosed.—C. A. **Gardner**: Contributions to the flora of Western Australia, No. 3.—L. W. **Phillips**: Essential oils of certain West Australian plants. The characters of the crude oil of *Eucalyptus spathulata*, *E. campaspe*, and *Agonis flexuosa* are described.

July 10.—Prof. A. D. Ross, president, in the chair.—The retiring president, Mr. E. de C. **Clarke**, delivered his presidential address on the pre-Cambrian system in Western Australia.

August 14.—Prof. A. D. Ross, president, in the chair.—W. H. **Shields**: Sand bars on intermittent rivers—a new method of treatment.—E. **Cheel**: A new myrtaceous plant, *Bæckea minutifolia*.—L. **Glauert**: Notes on fossil plants from Mingenew and Irwin River. The Jurassic *Otozamites feistmanteli* and Pagiophyllum and the Permo-Carboniferous forms Phyllotheca, *Sphenopteris lobifolia*, *Glossopteris browniana*, *G. indica*, *G. ampla* are described.

September 11.—Prof. A. D. Ross, president, in the chair.—E. **Ashby**: A new species and sub-species of Acanthochiton.—A. D. **Ross**: A critical examination of the Einstein eclipse tests. The photographic methods employed by the Lick Observatory and the University of Toronto parties reduced to a minimum the errors arising from film shrinkage or distortion by the optical system. Appreciable error from refraction in a solar atmosphere or from abnormal refraction in the earth's atmosphere is highly improbable. Gradation of intensity of the background of the photographs by coronal light appears to be the most uncertain factor, but, making all allowance for this, the final results are conclusively in support of Einstein's theory.—G. E. **Nicholls** and D. F. **Milner**: A new freshwater isopod allied to Phreatoicus. A description of a Crustacean, hitherto known only from a tiny pool fed by a small spring at the foot of Lesmurdie Falls in the Darling Ranges of W.A. A new genus, Hyperœdesipus, has been created for this form, which seems to occupy a position intermediate between Phreatoicus and Phreatoicoides—lacking the extended pleura and the epipodites of the former, but with the shape and general appearance of the latter, while the proportions are more nearly those of Hypsimetopus. It differs from all described Phreatoicidæ in possessing a relatively enormously developed swelling upon the propod of the male.

SYDNEY.

Royal Society of New South Wales, November 7.—Mr. R. H. Cambage, president, in the chair.—A. R. **Penfold**: The essential oil of *Darwinia grandiflora* and the

presence of a new acetic acid ester. The shrub occurs in quantity on the rocky ledges and in the ravines following the creeks of Narrabeen, Middle Harbour, and Berowra, near Sydney. Many distillations of the leaves and terminal branchlets yielded pale lemon-tinted pleasant-smelling oils containing d-a-pinene, an unidentified terpene boiling at 175-177° C. (dihydrochloride, m.pt. 53-54° C.), a sesquiterpene and sesquiterpene alcohol, stearoptene of m.pt. 103-104° C., and the acetic acid ester of a dextro-rotatory alcohol (called darwinol acetate) occurring to the extent of 30 per cent.—J. K. **Murray** and V. **Weston**: Notes on the bacteriology, titratable acidity, and H-ion concentration of some creams. A comparison is made between the individual microscopic count and the agar plate count of forty-two samples of cream. The average microscopic count of the raw creams was 659 millions per c.c. and the average for the agar plate counts 287 millions per c.c. Considerable differences of titratable acidity were found for a given H-ion concentration. No definite relationship between cream "grade" and H-ion concentration was found.—G. H. **Briggs**: The distribution of the active deposit of radium in helium and argon in the electric field. The percentage of radium-A atoms positively charged at the end of their recoil path in helium lies between 93·6 and 96·4 and is probably close to 93·7. For radium-B the percentage is probably greater than 96 per cent. In argon the values for radium-A and radium-B are respectively 61·8 and 81·8 per cent.

Official Publications Received.

Department of Commerce: Bureau of Standards. Scientific Papers of the Bureau of Standards, No. 476: A Study of Radio Signal Fading. By J. H. Dellinger, L. E. Whittemore, S. Kruse. Pp. 193-230. (Washington: Government Printing Office.) 10 cents.

Reprint and Circular Series of the National Research Council. No. 49: Statement of Activities of the National Research Council for the Year July 1, 1922–June 30, 1923. By Vernon Kellogg. Pp. 16. (Washington: National Academy of Sciences.) 25 cents.

Department of Agriculture: Federated Malay States. Bulletin No. 33: Wet Padi Planting in Negri Sembilan. By D. H. Grist. Pp. iv+92. (Kuala Lumpur.) 1 dollar.

The South African Journal of Science. Vol. 20, No. 1, October: Comprising the Report of the South African Association for the Advancement of Science, 1923, Bloemfontein. Pp. xlii+284. (Johannesburg.) 15s. net.

Bulletin of the American Museum of Natural History. Vol. 48, Art. 20: The Brachyuran Crabs collected by the U.S. Fisheries Steamer *Albatross* in 1911, chiefly on the West Coast of Mexico. By Mary J. Rathbun. Pp. 619-637+11 plates. (New York.)

Department of the Interior, Canada. Publications of the Dominion Astrophysical Observatory, Victoria, B.C., Vol. 2, No. 12: The Wedge Method and its Application to Astronomical Spectrophotometry. By H. H. Plaskett. Pp. 211-260. (Ottawa: F. A. Acland.)

Department of the Interior: United States Geological Survey. Water-Supply Paper 494: Outline of Ground-Water Hydrology; with Definitions. By Oscar E. Meinzer. Pp. iv+71. 15 cents. Water-Supply Paper 527: Surface Water Supply of the United States, 1921. Part 7: Lower Mississippi River Basin. Pp. iii+39+2 plates. 5 cents. (Washington: Government Printing Office.)

United States Department of Agriculture. Miscellaneous Circular No. 13: Local Names of Migratory Game Birds. By W. L. McAtee. Pp. 95. (Washington: Government Printing Office.) 20 cents.

Royal Asiatic Society (North China Branch). Extra Vol. 2: Anthropology of Northern China. By S. M. Shirokogoroff. Pp. vi+127. (Shanghai: 5 Museum Road.) 3 dollars.

Department of Agriculture. Report of the Director of Agriculture for 1922. Pp. D52. (Peradeniya, Ceylon.)

The Laboratory for Marine Investigations at Batavia: a New Tropical Marine Biological Station. By Dr. A. L. J. Sunier. Pp. 26+5 plates. (Batavia.)

Quarterly Journal of Experimental Physiology. Supplementary Volume: Containing an Abstract of the Proceedings of the XIth International Physiological Congress, held in Edinburgh, July 23-27, 1923. Pp. xxiv+243. (London: C. Griffin and Co. Ltd.) 30s.

Diary of Societies.

SATURDAY, JANUARY 19.

BRITISH MYCOLOGICAL SOCIETY (in Botany Department, University College), at 11 A.M.—Major K. W. Braid: Some Observations on "Stag-headed" Oaks.—W. J. Dowson: *Sclerotinia sclerotiorum* affecting Antirrhinums via the Stigma.—F. Howarth: The Sexuality of Ustilago.—Miss G. Lister: Mycetozoa from Northern India.—T. A. Sprague: The Principles of Nomenclature.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—R. Reynolds: The Mechanical Reproduction of Music.

MONDAY, JANUARY 21.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—E. J. Sewell: The Historical Value of the Book of Jonah (Gunning Prize Essay for 1923).

ROYAL GEOGRAPHICAL SOCIETY (at Lowther Lodge, Kensington Gore), at 5.—Capt. P. K. Boulnois: Field Longitudes by Wireless.

ROYAL SOCIETY OF MEDICINE, at 5.—Air-Commodore D. Munro, Sir Arthur Keith, Sir Duncan Rhind, Dr. J. Wallace, and others: Discussion on The Grading of the Population from the point of view of Bodily Fitness.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. R. St. Leger Brockman: The Problem of Drainage in Acute Appendicitis.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—E. H. Shaughnessy and others: Discussion on Broadcasting.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.—Prof. P. Nobbs: Architecture in Canada.

ARISTOTELIAN SOCIETY (at University of London Club), at 8.—Prof. H. Wildon Carr: Human Intercourse by Means of Speech.

ROYAL SOCIETY OF ARTS, at 8.—Dr. E. K. Rideal: Colloid Chemistry (Cantor Lectures (1)).

TUESDAY, JANUARY 22.

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Prof. W. E. Dixon: Drug Addictions (2).

INSTITUTION OF CIVIL ENGINEERS, at 6.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Kinematograph Group), at 7.—O. Bloch, L. Eveleigh, and others: Cinematograph Negative Film: What We Want and What We Get.

ILLUMINATING ENGINEERING SOCIETY (at Royal Society of Arts), at 8.—J. S. Dow and others: Discussion on Co-ordination of Research in Illuminating Engineering and Some Practical Applications.

WEDNESDAY, JANUARY 23.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. R. M. Handfield-Jones: Retro-peritoneal Cysts, their Pathology, Diagnosis, and Treatment.

GEOLOGICAL SOCIETY, at 5.30.—Dr. A. Smith Woodward: A Hybodont Shark (Tristychius) from the Calciferous Sandstone Series of Eskdale (Dumfriesshire).—Prof. W. S. Boulton: A Recently Discovered Breccia-Bed underlying Nechells (Birmingham), and its Relations to the Red Rocks of the District.

INSTITUTION OF CIVIL ENGINEERS (Students' Meeting), at 6.

ROYAL MICROSCOPICAL SOCIETY (Industrial Applications Section), at 7.—J. E. Barnard: Lecture Demonstration.—Capt. J. W. Bamfylde: Some Failures in Steel as revealed by the Microscope and recorded by Photography.—H. B. Milner: The Use of the Microscope in the Petroleum Industry.

ROYAL SOCIETY OF ARTS, at 8.—G. A. Smith: Cinematography in Natural Colours—Further Developments.

C.B.C. SOCIETY FOR CONSTRUCTIVE BIRTH CONTROL AND RACIAL PROGRESS (at Essex Hall, Strand), at 8.—Rev. Dr. D. Cameron: The Race Problem in Scotland.

BRITISH PSYCHOLOGICAL SOCIETY (Medical Section) (at Royal Society of Medicine), at 8.30.—Dr. H. G. Baynes: Primitive Mentality and the Unconscious.

THURSDAY, JANUARY 24.

ROYAL SOCIETY, at 4.30.—H. G. Cannon: The Development of an Estherid Crustacean.—*To be read in title only*:—Dr. C. Shearer: The Oxygen Consumption Rate of Parts of the Chick Embryo and Fragments of the Earthworm.—Dr. N. Annandale: The Evolution of the Shell-Sculpture in Freshwater Snails of the Family Viviparidæ.—Prof. B. Sahni: *Tmesipteris Vieillardi* Dangeard. An Erect Terrestrial Species from New Caledonia.—P. A. Buxton: Heat, Moisture, and Animal Life in Deserts.—A. W. Bellamy and Prof. C. M. Child: Susceptibility in Amphibian Development.

ROYAL AERONAUTICAL SOCIETY (at Royal Society of Arts), at 5.30.—Dr. J. R. Ramsbottom: Dopes and Fabrics.

INSTITUTION OF AUTOMOBILE ENGINEERS (Informal Meeting) (at Institution of Mechanical Engineers), at 6.30.—Demonstration of, and Discussion on, Testing Instruments.

FRIDAY, JANUARY 25.

PHYSICAL SOCIETY OF LONDON (at the Imperial College of Science and Technology), at 5.—E. A. Milne: Recent Work in Stellar Physics (Lecture).

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. S. Forsdike: Cancer of the Cervix.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—Major G. Le Q. Martel: Progress of Mechanical Engineering in the Military Service.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—R. H. Lawton: The Doone Country.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—E. Edser: Molecular Attraction and its Relation to Engineering.

ROYAL SOCIETY OF MEDICINE (Epidemiology and State Medicine Section), at 8.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir Aston Webb: The Future Development of London.

SATURDAY, JANUARY 26.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—W. Wallace: The Couperin Dynasty.

PUBLIC LECTURE.

THURSDAY, JANUARY 24.

LONDON (R.F.H.) SCHOOL OF MEDICINE FOR WOMEN, at 5.—Prof. Winifred C. Cullis: Respiratory Exchanges. (Succeeding Lectures on January 31 and February 7 and 14.)

Supplement to NATURE

No. 2829 JANUARY 19, 1924

Sun-spots as Magnets and the Periodic Reversal of their Polarity.

By Dr. GEORGE E. HALE, For. Mem. R.S., Mount Wilson Observatory.

THE revival of solar activity, now fairly begun after an interval of calm, prepares the way for a new attack on many classes of solar phenomena. Most important of these are the spots, of which the mode of origin and periodic variation in number and latitude are still unexplained. Recent observations at Mount Wilson, which have again shown the remarkable reversal of the magnetic polarity of sun-spots first detected at the opening of the last cycle of activity in 1912, now permit the formulation of the polarity law and help to define the conditions that must be recognised in any attempt to explain the constitution of the sun and other similar stars.

Sun-spots have been systematically observed ever since their discovery by Galileo in 1612 (Fig. 1). Their wide range in size, from single dots on the solar surface to complex groups enormously larger than the earth; their occurrence in zones, about 40° wide on either side of the equator, in which they suddenly appear, only to disappear after a life of days, weeks, or months; their rotation with the sun, not uniformly, as though attached to a solid sphere, but at a greater angular velocity near the equator than in higher latitudes; and their systematic variation in number, increasing and decreasing in a period of about 11 years, have long been known. If we plot a curve indicating the variation in the total area of sun-spots with the time, we find the successive maxima and minima illustrated in Fig. 2. At the maximum many spots can be seen on the sun daily, while near the minimum weeks may elapse without the appearance of a single spot. It will be noticed that following a minimum the spots increase rapidly in number toward the maximum, after which the rate of decrease toward the minimum is more gradual. It may be significant that curves representing the periodic variation in brightness of certain variable stars are very similar in character.

The sun-spot cycle is marked by another characteristic. The first spots of each new cycle appear at relatively high solar latitudes, ranging from about 15° to 40°. As the cycle progresses, the mean latitude of the spots decreases gradually, so that the last spots of the cycle, following the minimum, are near the equator. Moreover, the first spots of the new cycle are sometimes observed as much as two years before the last spots of the old cycle disappear (Fig. 3).

Let us next examine the visual structure of sun-spots and the character of the solar atmosphere in their vicinity. Fig. 4 is from a drawing by Langley of a large spot, showing the exquisite details visible through a telescope under the finest atmospheric conditions. Though other questions have been hotly contested,

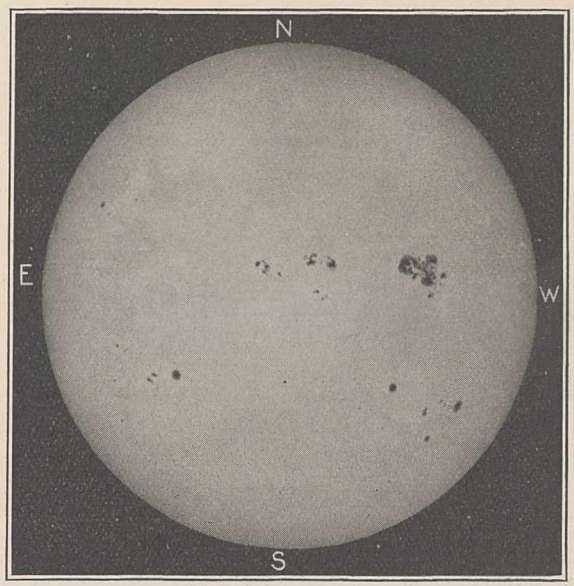


FIG. 1.—Direct photograph of the sun, showing the sun-spots visible on August 12, 1917.

visual observers have agreed that the appearance of inflow suggested by such drawings is in harmony with the facts. Indeed, the tips of the slender penumbral filaments have sometimes been seen apparently to break off and set sail across the dark central umbra of the spot.[1]

The early visual work therefore seemed to give clear evidence of indraught, but it failed to indicate the true nature of sun-spots. A vortex structure, analogous to that of terrestrial cyclones or tornadoes, had indeed been suggested by Sir John Herschel and by Faye; but

[1] The difficulty of harmonising this apparent inflow with the outflow at low levels indicated by the Evershed effect, supported by the reduced radiation attributable to expansion in the spot vortex, calls for renewed investigation of sun-spot structure by visual observers. A careful comparative study of the preceding and following members of bipolar groups is also needed.

although some three per cent. of all spots were admitted by Secchi to show a distinct vortical form, he agreed with practically all other experienced observers in rejecting this explanation of their nature. The hypothesis was attractive, but the conflicting directions of whirl in different parts of the same spot seemed incompatible with the idea of a great single whirl, such as we see on a considerable scale, with moderate wind velocities, in a terrestrial cyclone, and on a small scale, with very high velocities, in a hurricane or tornado.

Early work with the spectroheliograph, while it revealed great luminous clouds of calcium vapour floating at various levels above the spots in the solar atmosphere, failed to throw much light on the nature of sun-spots. Even the first monochromatic pictures obtained at the Yerkes Observatory with the hydrogen lines (Hβ, Hγ, Hδ) did not go much farther, though some of them revealed a suggestive definiteness of structure near spots, which was pointed out at the time. But as soon as the red Hα line could be tried on Mount Wilson in April 1908, the long search for significant configuration was at last rewarded (Fig. 5), and sun-spots were seen to be the centres of vast vortices in the solar atmosphere. The vortex hypothesis, though in modified form, was therefore revived by the writer, and spots were looked upon as solar storms resembling terrestrial tornadoes.

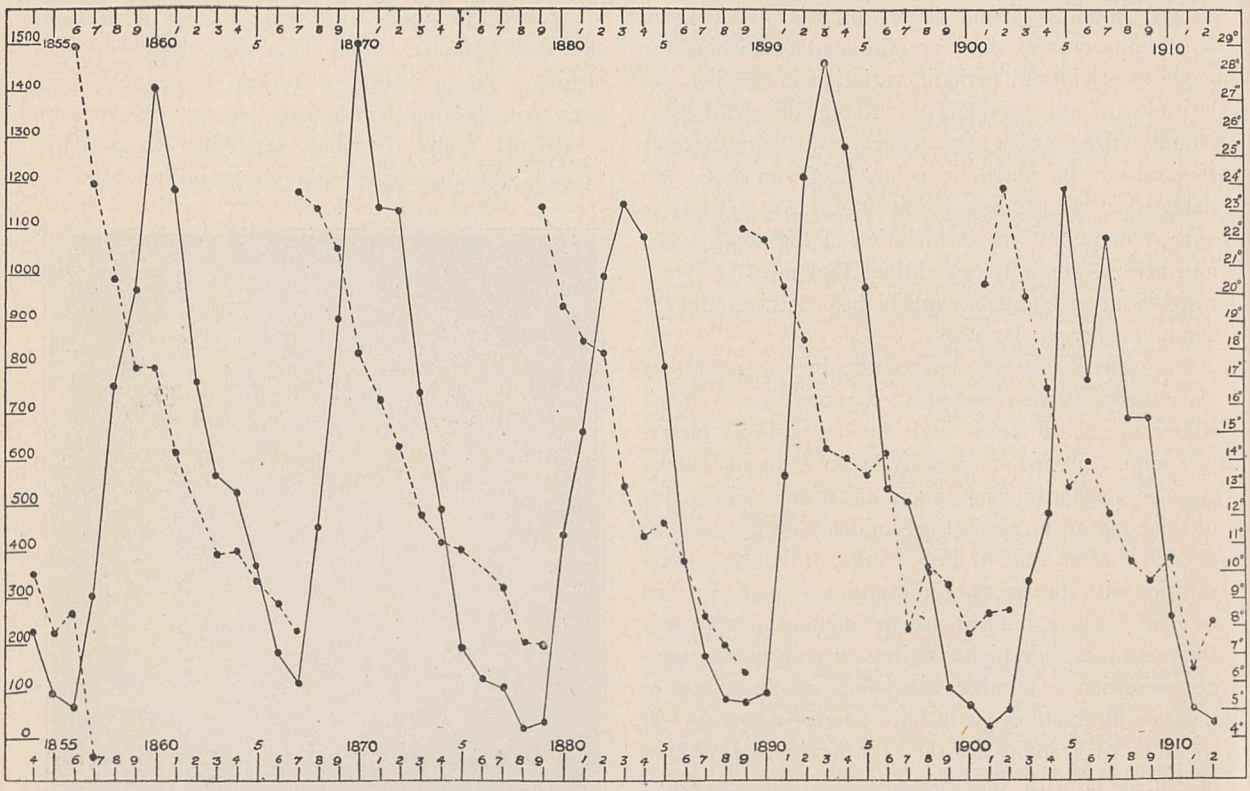


FIG. 2.—The periodic variation in the total area and mean latitude of sun-spots. The continuous line represents the total area of spottedness, derived by Maunder from the Greenwich photographs. The broken line, giving the mean latitude of the spots for the different years, shows how each cycle of solar activity begins in high latitudes during the minimum. (From Monthly Notices Roy. Astr. Soc., vol. 74, December 1913.) By courtesy of the Royal Astronomical Society.

Meanwhile the researches of Sir Joseph Thomson and others had shown that electrified particles, both positively and negatively charged, must occur in great numbers in a hot gaseous body like the sun. Assuming a preponderance of positive or negative charges in a solar vortex, their rapid revolution must give rise to a magnetic field, which was at once detected on Mount Wilson by observations of the Zeeman effect in the sun-spot spectrum.

In 1896 Zeeman had discovered that when a luminous vapour is observed in a powerful magnetic field most of the lines of its spectrum are separated into three or more components, polarised in distinctive ways which vary with the angle between the line of sight and the lines of force. The iron line λ6173, for example, is split in sun-spots into three components, the two outer ones elliptically polarised in opposite directions, the inner component plane polarised. Using a Nicol prism and quarter-wave plate over the slit of the spectroscope, a glance at this line shows the polarity of the spot, N (north-seeking pole) or positive if the red component is transmitted and the violet component extinguished by the "marked strip" of the compound quarter-wave plate, S or negative if only the violet component is seen (Fig. 6). Micrometric measurement of the distance between the components (which is directly proportional to the field-strength) gives the strength of the magnetic

field in the spot. Finally, a quantitative study of the polarisation of the components enables us to determine the angle between the lines of force and the solar surface in all parts of a spot.

This method, applied daily on Mount Wilson with a spectroscope of 75 feet focal length (second order spectrum) to all spots shown by the 16·5-inch solar image given by the 150-foot tower telescope, yields results such as those illustrated in Fig. 7, a drawing reduced from the original made at the telescope. Thousands of observations show that all spots contain magnetic fields; that the strength of this field (up to a

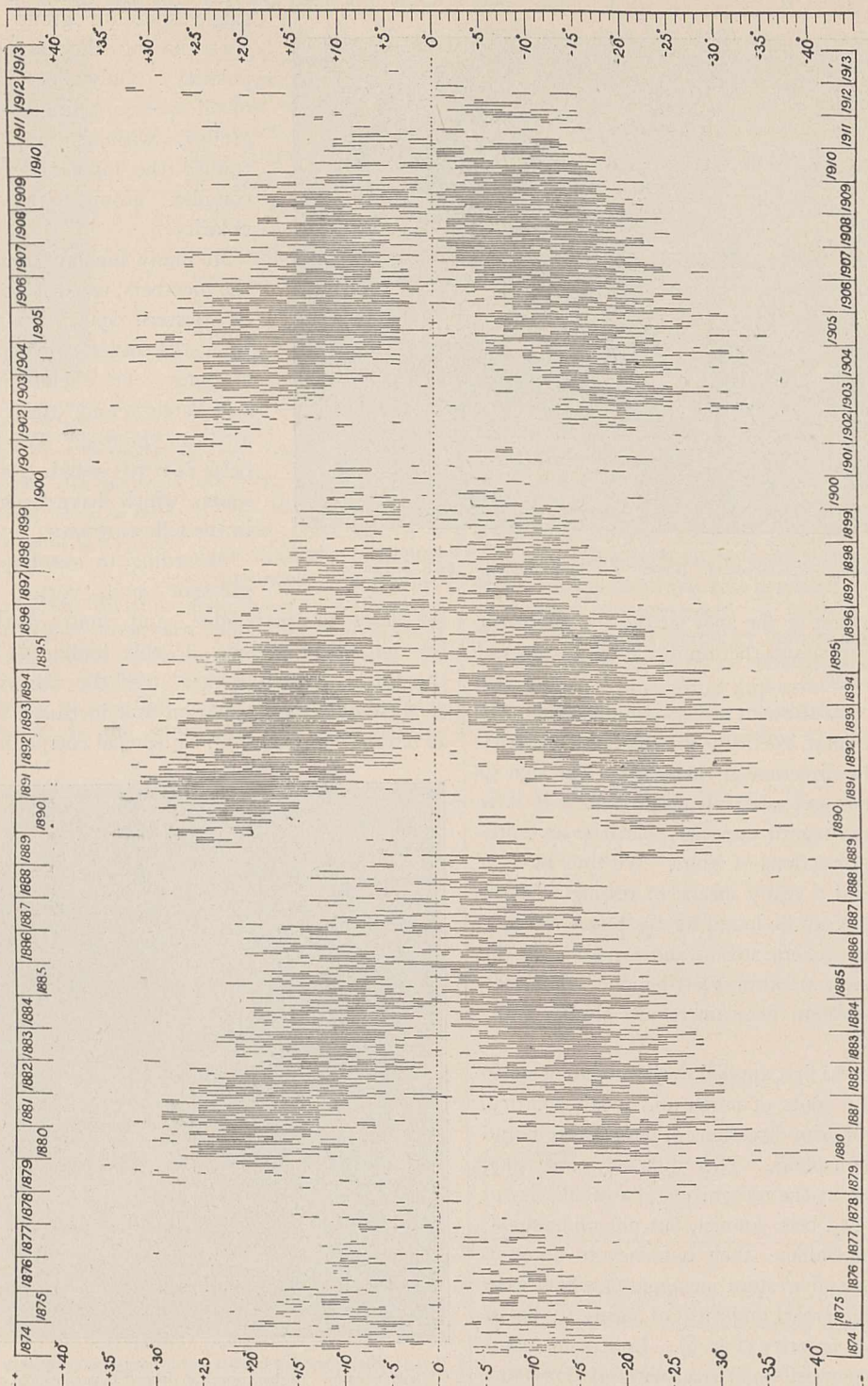


FIG. 3.—Maunder's "Butterfly" diagram. Each vertical line represents a sun-spot, regardless of its size, observed at Greenwich during the rotation of the sun at the north or south latitude indicated. Their average latitude steadily decreases as the cycle progresses, and the spots of each new cycle appear in high latitudes before the low-latitude spots of the old cycle completely disappear. (From Monthly Notices Roy. Astr. Soc., vol. 74, December 1913.) By courtesy of the Royal Astronomical Society.

certain maximum) increases with the diameter of the spot; and that the polarities, with a very small percentage of exceptions, follow a definite law which involves the position of the spot on the sun (north or south of the equator) and the number (odd or even) of the sun-spot cycle.[2]

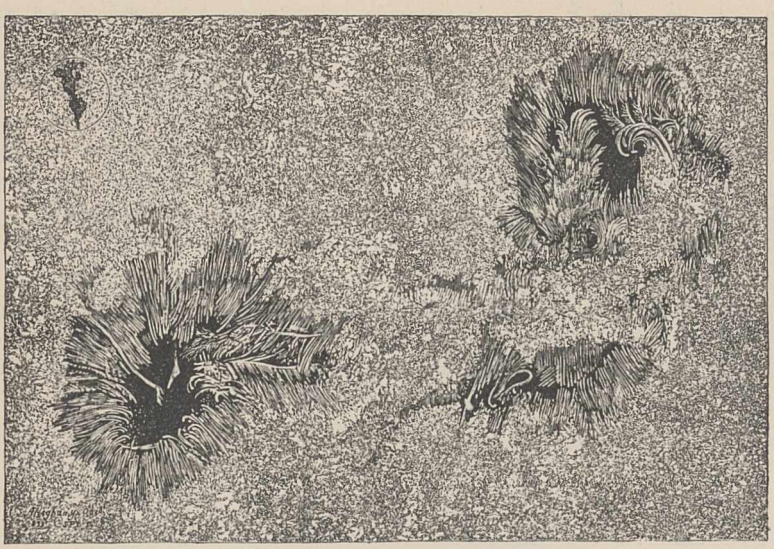


FIG. 4.—Langley's drawing of the sun-spot of March 3, 1873. The scale is indicated by the figure of the earth in the top left-hand corner. (From "The New Astronomy," by S. P. Langley.)

If we assume that the sign of the dominant charge is the same in all solar vortices, the observed polarity depends upon the direction of the whirl. The sign of this charge is not yet certainly known, but if it is invariable we may regard opposite polarities as representing opposite directions of whirl. We thus have in the polarity record a ready means of testing whether any solar analogue can be found for the terrestrial law, which states that cyclonic storms and tornadoes in the northern hemisphere are always left-handed, while such storms in the southern hemisphere are always right-handed.

When this test was first applied to the sun an obstacle was encountered: spots of north and south polarity, taken to mean opposite directions of whirl, were found in the same hemisphere. This difficulty was soon removed, however, by the recognition of a peculiarity of sun-spots which had been known, but not understood, since the time of Galileo—their tendency to occur in pairs, the eastern and western members of which were discovered in the great majority of cases to be of opposite magnetic polarity (Fig. 9). In streams composed of many spots of small size, without dominant members, the groups of spots lying at opposite ends of the stream are usually opposite in polarity. Some 60 per cent. of all spots are of this definite bipolar type. Of the remainder, about 30 per cent. show a tendency toward the bipolar type, marked by the presence of calcium or hydrogen flocculi following or preceding a single spot (or group of small spots having the same magnetic polarity). Only about 10 per cent. of all spots are single or unipolar groups, without any tendency toward the bipolar form. A few complex groups are of mixed polarity.

In many bipolar groups one of the members, usually the preceding or western spot, is much larger than the other, which sometimes becomes very small, disappears completely, and then reappears after an interval. We have thus been led to search for invisible spots, which have been detected in the following way.

According to our hypothesis, a sun-spot is a vortex in which the gases are expanded, and consequently cooled, by centrifugal action. If this cooling is sufficient, the gases appear darker over the vortex because of their decreased radiation and increased absorption at reduced temperature. Chemical compounds, recognised by their characteristic bands in the sun-spot spectrum, also form in these cooler regions. But it is quite conceivable that some solar vortices may exist in which the cooling is insufficient to produce a per-

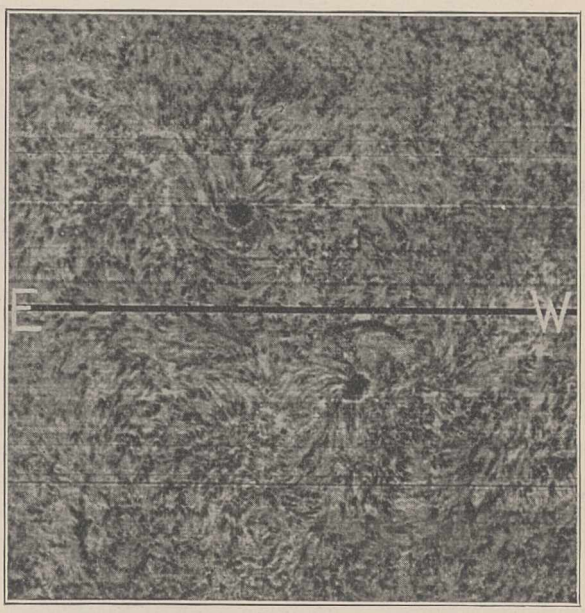


FIG. 5.—Right- and left-handed sun-spot vortices, on opposite sides of the solar equator. The hydrogen atmosphere above sun-spots, photographed with the spectroheliograph at Mount Wilson on October 7, 1908. These spots were found to be of opposite magnetic polarity.

[2] For a full description of the methods and results of this investigation see "The Magnetic Polarity of Sun-spots." Contributions from the Mount Wilson Observatory, No. 165. *Astrophysical Journal*, vol. 49, pp. 153-178, 1919.

ceptible change in brightness. A magnetic field sufficiently intense to be detected by a very powerful spectroscope may nevertheless be present in such cases.

In large spots the iron line λ6173 is split into three components by the intense magnetic field. In the weak field of the smallest spots it is not separated, but widened very slightly toward red or violet. As a moving object is more readily visible than a fixed one, an oscillating half-wave plate, mounted above the quarter-wave plate and Nicol prism, is employed to cause this widening to appear alternately toward red and violet. When an invisible spot (usually sought for in the flocculi following a single spot) crosses the slit, its presence is betrayed by a slight oscillation of the line at the corresponding point.

FIG. 6.—The Zeeman triplet λ6173 in the sun-spot spectrum. Photographed in the second order spectrum of the 75-foot spectrograph of the Mount Wilson 150-foot tower telescope. The polarity of the spot is determined by the transmission of the red or violet component of the triplet by the "marked strip" of the compound quarter-wave plate.

In this way many invisible spots have been found by the Mount Wilson observers, sometimes several days before or after their appearance as visible spots. In other cases the visible stage was never attained. The discovery of invisible spots has thus made it possible to study the embryonic and post-mortem stages of visible sun-spots, and has strengthened the reasoning that holds the bipolar spot to be the typical group.

We may now take the first step in formulating a law of sun-spot polarities. Giving chief weight to bipolar groups, and regarding single spots followed by a train of flocculi as the preceding members of incomplete bipolar spots, and single spots preceded by flocculi as the following members of such groups, we first classify the spots observed prior to the minimum of 1912. These were only 26 in number, as our attention at that time was chiefly concentrated upon the magnetic phenomena of a few large spots. In seven groups in the northern hemisphere, the polarity of the preceding spot, characterised by the violet component of the λ6173 line, was S (south-seeking pole) or negative, and that of the following spot N or positive. Seventeen groups in the southern hemisphere gave opposite polarities, *i.e.* N for the preceding and S for the following members. The only exceptions to the rule thus indicated were shown by two groups in the southern hemisphere, with polarities opposite to those of the seventeen other southern groups.

These 26 groups, observed between June 1908 and December 1912, ranged in latitude from 18° to 3°, with an average latitude of 9°. When the first spots of the new cycle began to appear in high latitudes near the minimum, we were surprised to find that their polarities were reversed, preceding spots in the northern hemisphere now having N or positive polarities, instead of the S polarities invariably found for preceding spots in this hemisphere before the minimum. The southern spots also showed reversed polarities. As the cycle advanced, and hundreds of spots in high latitudes were observed, the same new rule persisted, with a very small percentage of exceptions. A radical change, of the most fundamental character, had apparently occurred.

This sudden reversal of polarities was wholly unexpected, and apparently impossible to explain by any known theory of the solar constitution. No prediction could safely be made regarding the date of the next reversal of polarities, which might occur either at the maximum or at the minimum of the sun-spot period. Therefore any attempt to formulate a polarity law had to be deferred until after the minimum of 1923.

During the interval of nearly eleven years which has since elapsed, the polarities of 2110 spot-groups of this cycle have been observed. Their average latitude has steadily decreased from 22° (ranging from 34° to 13°)

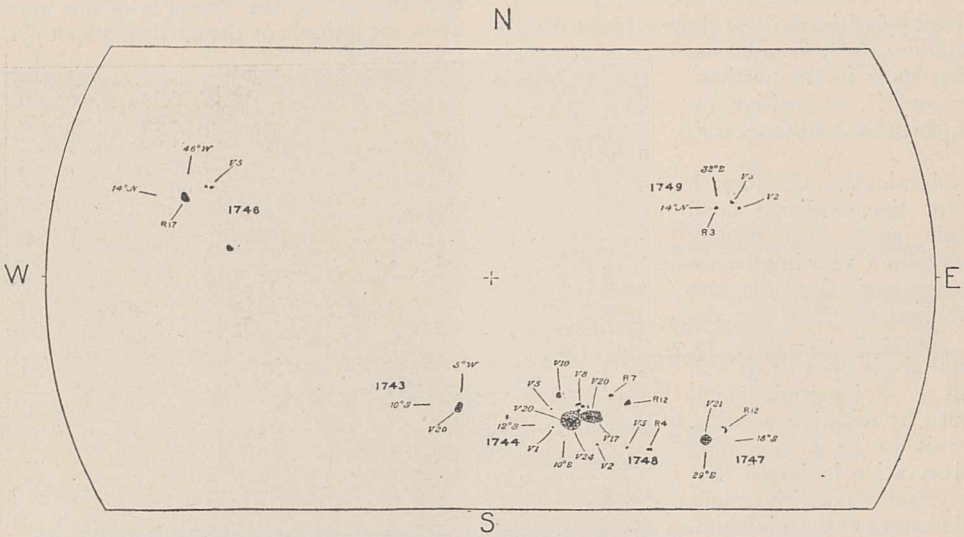


FIG. 7.—Polarities and field-strengths of sun-spots observed at Mount Wilson on September 27, 1920. R 17, for example, indicates that this part of the spot-group was of north or positive polarity, with a field-strength of 1700 gausses. The regions of opposite polarity are designated by V. In this figure the preceding spots are shown at the left, as at the focus of the tower telescope.

in 1913–1914 to 8° (25° to 0°) in 1923. All unipolar and bipolar groups, with only 4 per cent. of exceptions, have shown the same polarities as those observed immediately after the minimum: S, or negative, for preceding spots in the northern hemisphere, and N, or positive, for preceding spots in the southern hemisphere.

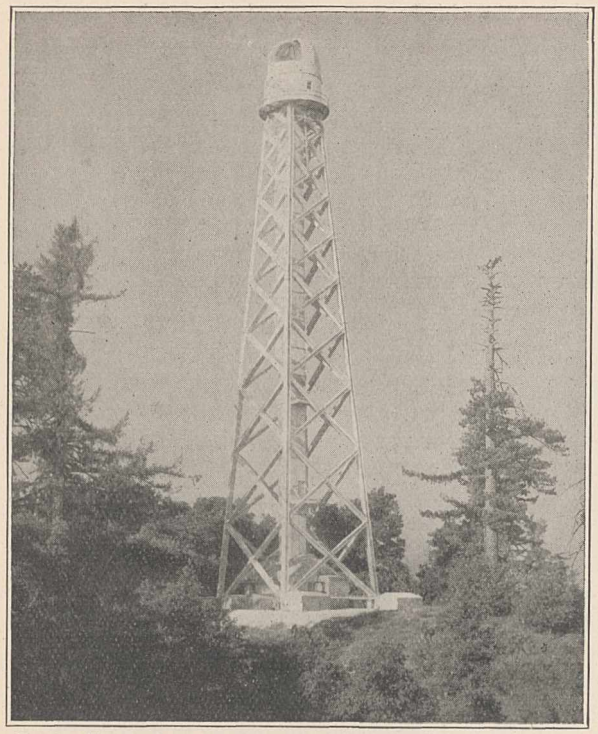


FIG. 8.—The 150-foot tower telescope of the Mount Wilson Observatory. A spectrograph of 75 feet focal length, mounted in a well beneath the base of the tower, is used daily to determine the magnetic polarity and field-strength of all sun-spots seen on the 16·5-inch solar image.

As the cycle waned, a close watch was kept for the occasional small high-latitude spots that usually appear more than a year in advance of the vigorous beginning of a new cycle. The first of these was detected by Ellerman on June 24, 1922, a small single spot at 31° N. latitude and 10° E. longitude, found to have south or negative polarity. Assuming this to be a preceding spot, the observation indicated that a general reversal of polarities might be expected to occur at the minimum. This has actually taken place, as may be seen by a glance at the polarities of the new cycle (high latitude) spot-groups observed from June 1, 1922, to date, shown graphically in Fig. 10.

These observations, in confirmation of those made eleven years ago, indicate that near the time of the sun-spot minimum four spot zones, characterised by distinct magnetic polarities, may co-exist on the sun (Fig. 11). With the single exception of a spot at S 25°, observed only on September 7, 1923, the maximum latitude of the spots showing the polarity characteristic of the old cycle was 15°. The latitude of the new cycle spots, of opposite polarity, ranged from 40° to 18°. In the southern hemisphere, if we exclude the short-lived spot at S 25°, the interval in latitude between spots of opposite polarity was only three degrees. The corresponding interval between old and new cycle spots in the northern hemisphere was eight degrees. As the illustrations indicate, these zones of opposite polarity in the same hemisphere last only a year or two near the time of sun-spot minimum. While they exist, as on September 17 and 18, 1923, two bipolar spot-groups of opposite polarity may occur simultaneously in the same hemisphere less than fifteen degrees apart. The recurrence of these zones is illustrated in Fig. 12, which shows the approximate variation of mean latitude and the polarities of unipolar and bipolar spots observed magnetically from 1908 to November 1923 by Hale, Ellerman, Nicholson, Joy, Pettit, and others. Miss Mayberry has assisted in the work of tabulation and classification, most of which has been done by Nicholson.

The sun-spot period, regarded in the customary way as representing the variation in the number or total area of spots on the sun, irrespective of their magnetic polarity, is about 11·1 years. But if we define the period as the interval between successive appearances of spots of the same magnetic polarity, we thus find it to be twice as long.

It seems very probable that the dominant electric charge in all spot vortices is of the same sign, and that opposite polarities represent opposite directions of whirl.[3] In any event, we have no reason to suppose that the sign of the charge is at any time dependent upon the latitude or the particular spot cycle. Thus it is difficult to escape the conclusion that corresponding

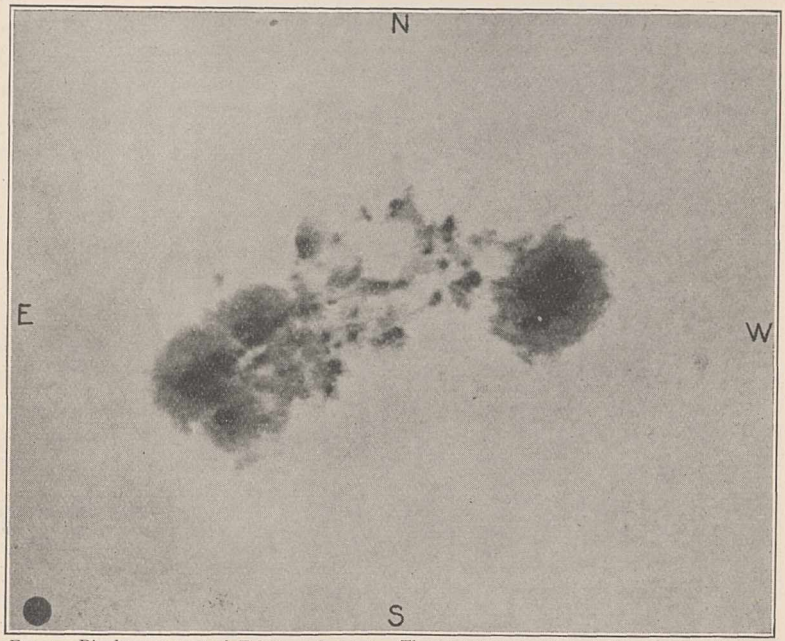


FIG. 9.—Bipolar sun-spot of February 8, 1917. The preceding (west) and following (east) spots of these characteristic groups are of opposite magnetic polarity. The scale is shown by the disc in the bottom left-hand corner, representing the size of the earth.

[3] Several writers have inferred from our polarity observations that electrified charges of opposite sign are emitted from spots of opposite polarity. There seems to be no evidence to warrant such a belief.

spot vortices of successive cycles whirl in opposite directions—a phenomenon for which the nearest terrestrial equivalent would be a periodic reversal of the direction of whirl in cyclones and tornadoes.

panied by any radical change in the law of the sun's axial rotation, either at the spot level or at any elevation above it. The general magnetic field of the sun showed no reversal of polarity. As for the vortices represented

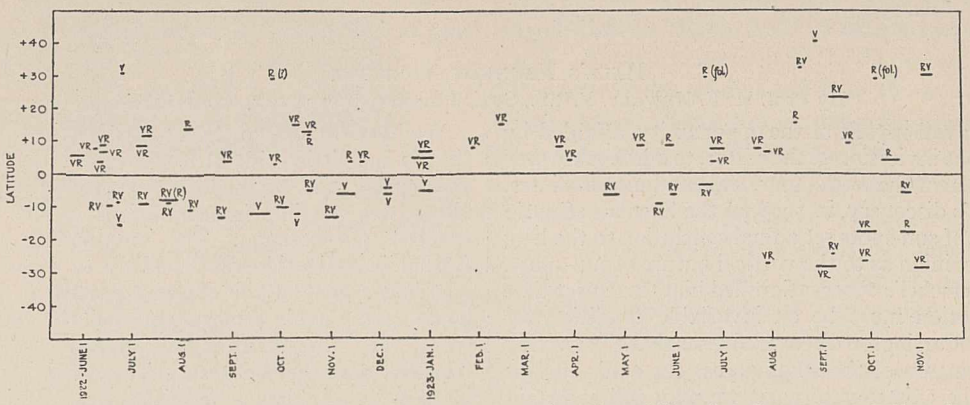


FIG. 10.—Solar latitudes and magnetic polarities of sun-spots observed at Mount Wilson from June 1, 1922, to November 10, 1923. The low-latitude spots are those of the old cycle. The high-latitude spots, the first of which appeared on June 24, 1922, belong to the new cycle and are of opposite magnetic polarity (with one exception). The letter (R or V) representing the preceding spot is on the right.

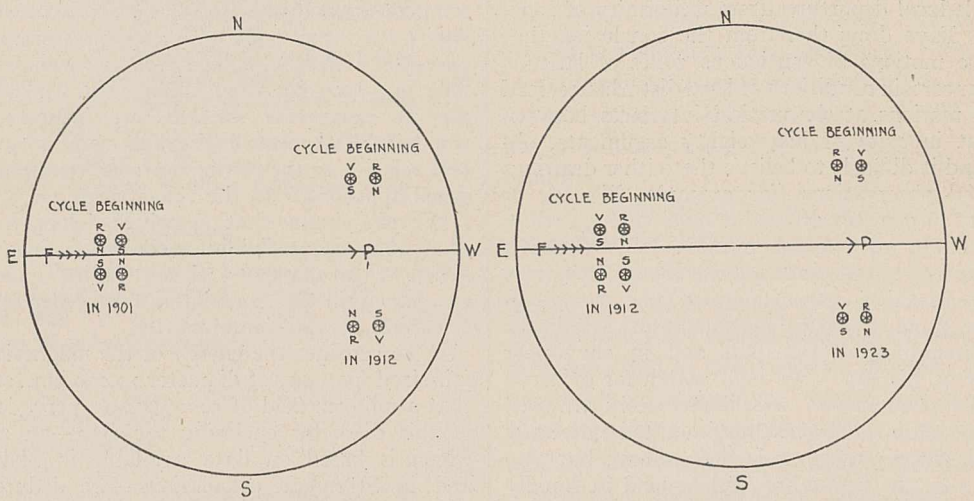


FIG. 11.—Sun-spot zones during the minimum of solar activity. Two zones in each hemisphere, in which the spots are of opposite polarity, exist for about two years at the time of each sun-spot minimum.

The explanation of this remarkable effect, which perhaps involves the whole problem of the internal constitution of the sun and of dwarf stars in general, may not be easily found. Observations carried through the minimum of 1912 do not indicate that it is accompanied by the structure of the hydrogen flocculi, we have not yet found any evidence of reversal in their direction of whirl at the spot minimum. A further study of this question, in continuation of much previous work, is now in progress. Meanwhile it may be remarked that

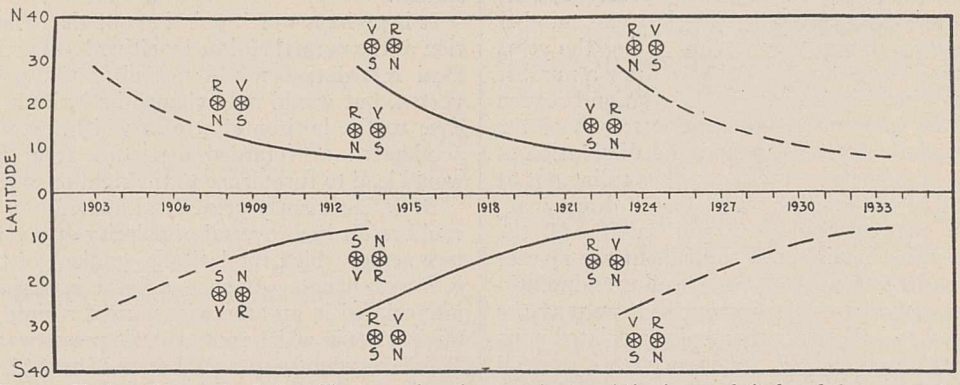


FIG. 12.—The law of sun-spot polarity. The curves show the approximate variation in mean latitude and the corresponding magnetic polarities of 2136 sun-spots observed at Mount Wilson from 1908 to 1923. The preceding spot is on the right.

the available evidence seems to point to the existence and origin of the spot vortex (the vortex which gives rise to the magnetic field) beneath the photosphere. The vortex represented by the hydrogen flocculi, shown by spectroheliograms taken with the Hα line, is apparently a secondary phenomenon lying at a higher level, where it is quite conceivable that its direction of whirl may be independent of that of the spot vortex below it.

Hale's Magnetic Vortices.

By Prof. H. F. Newall, F.R.S., Solar Physics Observatory, Cambridge.

I gladly avail myself of the opportunity, afforded by the courteous invitation of the editor, to add a few words of admiration of the work of Dr. Hale and his associates.

Dr. Hale's discovery, in 1908, of the Zeeman effect in the spectra of sun-spots set a final conclusion to the long conflict of opinion as to the vortical nature of sun-spots. Sir John Herschel's observations led him to suspect that vortical motion must be an invariable condition for sun-spots. Carrington discovered later that the varying daily movements of the spots across the sun's surface indicated the existence of what we may call a certain average régime of rotational motion wherein there is a maximum angular velocity in the equatorial zone about the sun's axis, whilst in the neighbouring zones on either side of the equator the angular velocities gradually diminish as higher latitudes are reached, with very considerable local departures from uniformity of zonal velocities. Faye drew therefrom the conclusion that the relative motions of contiguous zones of latitude must, under certain conditions of local disturbance, lead to vortical motions at the vertical interfaces between zones. But in spite of his weighty arguments, observers found it difficult to believe that either drawings from careful observations (for example, Fig. 4), or photographs of complex groups of spots (Fig. 9), really gave indications of vortical motion. Hence Hale's discovery in 1908 that signs of definite vortical structure could be seen in his spectroheliograms (Fig. 5) came as a convincing proof of vortical motion, at any rate in the lateral surroundings of sun-spots and in the upper atmosphere of the sun. His bold search for evidence of Zeeman's phenomenon was immediately crowned with success. Sun-spots were thus found to be the seats of magnetic fields, strongest in the umbræ, but also extending over the penumbræ and beyond in rapidly diminishing strength.

An important discovery is often followed by a period of apparent stagnation. But, in the case before us, the advance has been rapid and continuous; for the Mount Wilson observers have been assiduously measuring the field strengths and polarities of a vast number (more than 2000) of sun-spot groups during the years 1908–1923, and have thus been able to draw a number of important conclusions as to (1) the relation between the size of the spot umbræ and the strengths of the observed magnetic fields; (2) the rapid diminution of the strength of field above the spots, thus ruling out at the sun's end of the line the possibility of direct magnetic action between sun-spots and earth; (3) the curious association (maintained throughout the 11-year cycle) of opposite polarities with the leading and following members of "bimaculous" groups—if we may use this ugly word to indicate Carrington's associated pairs of spots; and lastly (4) the very remarkable reversal of polarity of "bipolar" groups in successive 11-year cycles. It is scarcely possible to use restrained language in expressing admiration for the superb mass of observational material systematically gathered and discussed by Hale and his associates.

We have become so accustomed to the 11-year cycle that it is a little difficult to readjust ideas to a 22-23-year cycle; and we must be content to look quietly at alternative possible interpretations of the newly discovered phenomenon. The outstanding points for further investigation relate chiefly to determining the seat and extent of the effective vortex in the various levels of the sun's atmosphere, and the source of the energy and the mode of its conversion. The energy relations are somewhat surprising, and it may be of interest to set forth a few instances. It is not very unusual to find a spot showing a "proper motion," relative to the zone of latitude in which it is situated, of as much as 20 minutes of arc per diem—about 4000 km./day or about 40 m./sec. Assuming an average density of 1/200th of the density of air at normal temperature and pressure, corresponding to air at 5460° Abs. ($=20\times273°$) and 1/10 atm. pressure, the kinetic energy of a stream of gas 20,000 km. wide, 100,000 km. long, and 1000 km. deep—dimensions which seem in no way to exaggerate features seen in some of Hale's wonderful Hα spectroheliograms—amounts to 2×10^{29} ergs relative to the contiguous zone travelling with the speed appropriate to the velocity régime.

We may assume that quantities of energy of this sort of amount are available for conversion into the eddies which we call sun-spots, without calling upon sources of energy within the sun's interior, whether of indraught or explosive expulsion of matter.

If we consider the energy of the magnetic field in a fair-sized spot, say of diameter 10,000 km., and assume that a uniform field of 5000 gausses pervades a sphere of this diameter enclosing the spot—an assumption which is based on data available in Hale's papers and in Störmer's calculations—we deduce a value $(\mu H^2/8\pi)\times\text{volume}=0{\cdot}5\times10^{33}$ ergs, taking μ as unity. The energy required to establish the magnetic field is nearly the same as the total output of radiant energy emitted by the whole sun in about one-seventh of a second.

It is perhaps worth pointing out that a local mitigation of the normal régime by either local acceleration or local retardation would not alter the polarity of a vortex, but would only change its latitude with reference to the horizontal stream which, by reason of its accelerated or retarded departure from the régime, would lead to turbulence to the right or to the left of it.

But a sufficiently great local *inversion* of the régime could result in a reversal of polarity at a vertical interface across which the latitude gradient of the velocity is large enough. If such a local inversion occurred intercalated in an otherwise normal régime, conditions might arise in which spots of both polarities are formed. These considerations would seem to provide conditions for the production of either polarity or both, but they leave the correlation of inversion with alternative cycles still to be explained, and would need to be elaborated to explain the maintenance of reversed polarity through a cycle.

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